SCIENTIFIC AMERICAN SUPPLEMENT. No 1579

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Scientific American. established 1845.
Scientific American Supplement. Vol. LXI., No 1579.

NEW YORK, APRIL 7, 1906.

Scientific American Supplement. $5 a year
Scientific American and Supplement. $7 a year.

THE ISTHMUS OF TEHUANTEPEC AND ITS INTER-OCEAN RAILWAY.

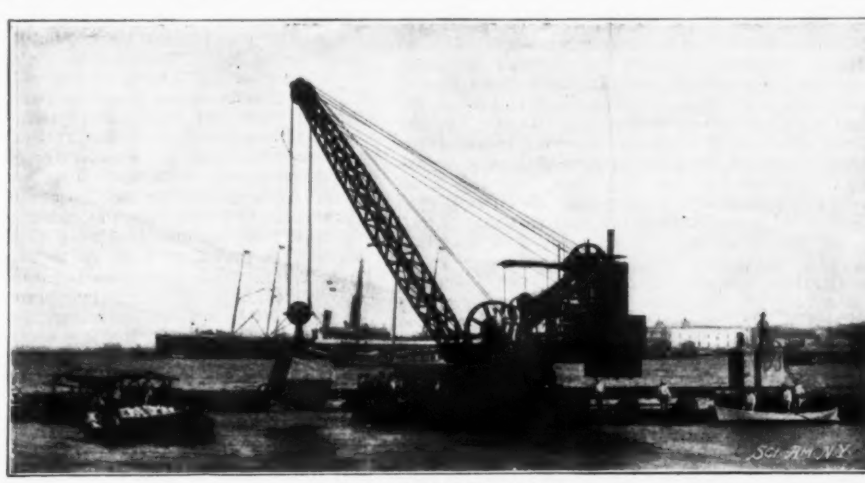
The following report from Special Agent Pepper on the construction of a railway across the Isthmus of Tehuantepec under auspices of American capital and its possible relation to the Panama Canal, contains information that has special value at this time:

The Isthmus of Tehuantepec proper lies between the parallels of north latitude 16 deg. and 18 deg. and the meridians of west longitude 94 deg. and 95 deg. The Coatzacoalcos River, which rises in the foothills of the Sierra Madre Mountain Range, empties into the Gulf of Mexico, and at its mouth a natural harbor is formed which is obstructed by a bar. On the Pacific coast there is no natural shelter; in fact, hardly an open ocean roadstead. The Tehuantepec National Railway joins these two points. As the bird flies it is about 125 miles across the isthmus from ocean to ocean. By the route which the railroad is compelled to follow the distance is 190 miles.

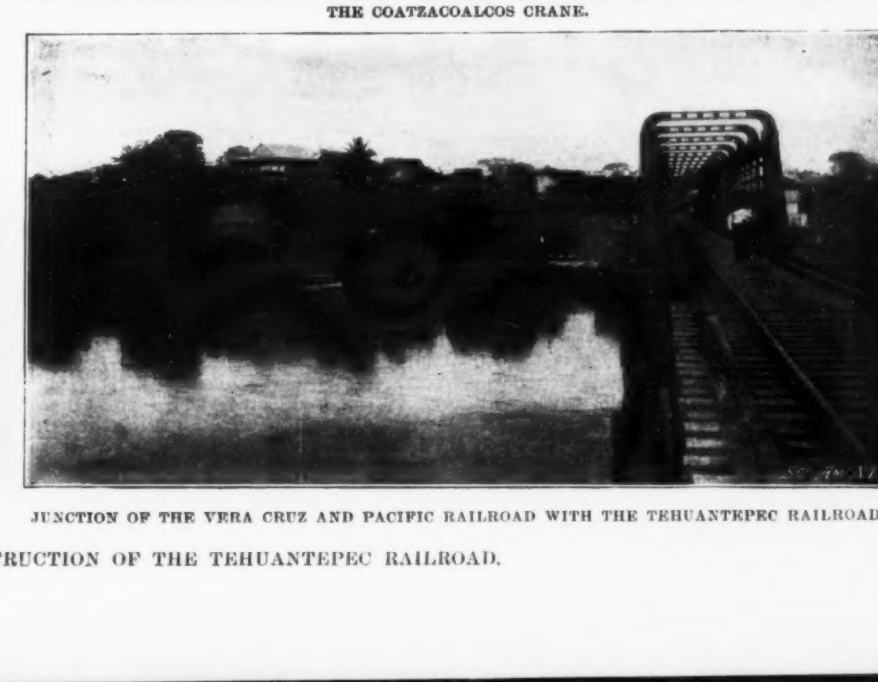
Long before Capt. James B. Eads planned a ship railway across Tehuantepec, attempts were made both at building ordinary railroads and at canal digging. In 1881 and subsequent years rails were laid at either end of the route, but it was not until 1892 that serious efforts were made to unite these sections and form a through line. When this was done the construction was so poor that it was of little use for traffic. In 1898 the enterprise was taken in hand by the firm of Pearson & Son, which built the drainage canal for the city of Mexico. Their contracts with the Mexican government were modified and amended in 1902 so as to include substantially the entire rebuilding of the railway and the construction of the harbor works at Coatzacoalcos and Salina Cruz. The engineering conditions for the railway construction require a gradual ascent from the mouth of the Coatzacoalcos River, crossing many affluents of that river, till the tableland is reached. There is a depression at the Jaltepec River 79 miles from Coatzacoalcos. This river is spanned by a steel bridge 560 feet in length. Between this point and the Atlantic the grades are about 60 feet to the mile. The real grade, however, may be said to begin at the point known as Santa Lucrecia, where the Jaltepec River is crossed. The Malatengo Canyon is entered about 38 miles beyond Santa Lucrecia. Here the route is through rock cuts and chasms, which are bridged, gradually climbing upward to Rincon Antonio, where the railway company has established its yards and shops. A short distance beyond Rincon Antonio the Chivela Pass is entered and crossed at a height of 735 feet above sea level. From this highest point the descent to the Pacific is abrupt and the steepest grades are encountered. Through the Chivela Pass the grades reach 116 feet to the mile. On the Pacific slope the route follows the partial course of the Tehuantepec River, but leaves it before Salina Cruz is reached, which is the terminus. In

THE CITY OF TEHUANTEPEC, THROUGH WHICH THE RAILROAD PASSES.

THE WEST BREAKWATER CRANE.



THE COATZACOALCOS CRANE.



JUNCTION OF THE VERA CRUZ AND PACIFIC RAILROAD WITH THE TEHUANTEPEC RAILROAD.

Photographs copyrighted by C. B. Waite.

THE CONSTRUCTION OF THE TEHUANTEPEC RAILROAD.

the reconstruction of the road many of the heaviest grades were reduced and the curves straightened. As it exists to-day the Tehuantepec National Railway is an unusually good work of railroad construction and seems capable of sustaining all the freight traffic that can be obtained for it. The road is standard gage of 4 feet 8½ inches. For the clayey soil there is rock ballast and gravel. The ties are creosoted pine, California redwood, and native hardwood. Eighty-pound steel rails are employed. The best steel bridges with solid masonry and abutments are utilized wherever a river is to be crossed, and this is especially important on account of the torrential rains in the wet season. The locomotives and rolling stock are of the best equipment. With this solid construction and with such rolling stock there seems to be no question about the railroad standing whatever strain may be put upon it.

The Gulf or Atlantic terminal at the mouth of the Coatzacoalcos River is 160 miles from the confluence with the Malatengo River. At its mouth the Coatzacoalcos is 2,000 feet wide. The engineering problem of dredging a channel through the bar to the sea has been met by following the Eads plan at the mouth of the Mississippi. Converging jetties have been built from the mouth of the river to the sea in which the current is confined and scours out the channel. The normal bar is 14 feet on the crest. The channel has been deepened to 33 feet and is 328 feet wide. In this way a deep inner basin has been created. The jetties or dikes converge from 3,445 feet at the shores to 919 feet at the sea ends. There are 1¼ miles of wharfage, steel wharves, and the plans include nine warehouses, each 400 feet in length.

At Salina Cruz, on the Pacific, the engineering problem was much more serious than on the Gulf. The northers which sweep across the Isthmus beat the surf out to the sea, and since there is no natural shelter it was necessary to construct both an outer or refuge harbor and an inner harbor with wharves and drydocks. The only advantage offered by nature was the rock promontory 250 feet high, from the base of which breakwaters could be extended. These breakwaters have been constructed with the convex sides turned seaward. The jetties at the entrance are 656 feet across. The east breakwater is 1 kilometer, or about five-eighths of a mile, long. It extends out for 1,200 feet in a straight line from the shore, then bends for 825 feet in a curve with a radius of about 1,900 feet, and then continues in a straight line for about 1,235 feet.

The west breakwater is about 1,900 feet long, extending in a straight line for 850 feet and then curving for about 370 feet on a radius of 325 feet and continuing in a straight line for 680 feet. Across the rear of the protected area a line of wharfage extends, opening to the interior basin, where the depth is to be 33 feet.

The rock for these harbor works was obtained from the Mixtequilla quarries, which are adjacent to the railroad.

Though the harbor works at Salina Cruz have not been completed, a contract has been made by the firm of Pearson & Son and the Mexican government, operating in partnership, which contemplates unloading vessels and transshipping the cargo as early as June of the present year. From information given me at Salina Cruz, I am inclined to place the date at not earlier than September. The contract, however, insures international traffic for the Tehuantepec Railway. It was made with the American Hawaiian Steamship Company, and I am informed that under the terms it is to continue till the opening of the Panama Canal to traffic, no fixed year being designated. The American Hawaiian Steamship Company is to operate a triangular line of steamers touching at San Francisco, Salina Cruz, and Hawaiian points. It is also proposed to have a direct service for full cargoes between Hawaii and Salina Cruz, while the triangular service will pick up New York and Pacific coast way freight. There are to be nine steamers with a cargo capacity of 8,500 tons each.

On the Atlantic side a weekly Gulf service is to be maintained between Coatzacoalcos and New York and Coatzacoalcos and New Orleans, respectively. Competition may be with the Pacific Mail for New York and Pacific coast freight, since the latter company has arranged for bi-monthly calls at Salina Cruz. Heretofore the service has been left to the German line, the Kosmos, since other lines claimed there was not freight enough for them to pay the port charges and undergo the risk of poor harbor facilities.

As regards cargo handling and transshipment, until experience has shown what can be done, the estimates of the probable traffic across the Isthmus of Tehuantepec are more or less guesswork. It is stated that the American Hawaiian Steamship Company handles 250,000 tons of the Hawaiian sugar crop, and it has been assumed that this cargo can be transshipped more quickly than the miscellaneous freight. One estimate has been that with the very modern facilities for loading and unloading which will be established, a cargo of 5,000 tons can be transferred from a steamer to the cars at Salina Cruz in ten hours, that the transport across the isthmus will not require more than fourteen hours, and that another ten hours will enable the cargo to be transshipped at Coatzacoalcos, making a total of thirty-four hours in all. I have met a number of railway men in Mexico who have expressed their doubts whether any such amount of freight can be transferred across the isthmus in the time stated. Allowing for excellent roadbed, ample sidings and switches, and rolling stock in prime condition, they have still been skeptical whether the road will serve a large amount of international traffic without being double tracked. However, the facilities appear to be sufficient for the traffic that is already insured.

The financing of the Tehuantepec Railway and of the harbor works at both terminals has been accomplished with the same persistency of purpose that the Mexican government has shown in other great national projects. While exact figures cannot be given, a review of the numerous and varied appropriations and their reduction from Mexican currency to a gold valuation seems to indicate an expenditure of approximately $35,000,000 on the railway and the harbor works at Coatzacoalcos and Salina Cruz. Under the terms of the contract which was made with Pearson & Son in 1902, the railway is to be operated in partnership for fifty-one years. The working capital was supplied jointly by the government and the contracting firm. After reciting various conditions in regard to operating expenses, etc., 5 per cent on capital stock, and interest on loans, the provision is made that the surplus for a period of thirty-six years shall be distributed in the proportion of 65 per cent to the government and 35 per cent to the contractor. After that the government's share increases gradually. In the preliminary work the railway corporation was organized with funds furnished jointly by the government and Pearson & Son, but it was also found necessary to emit two loans of $7,000,000 and $3,300,000, respectively, in Mexican currency, at 6 per cent interest until the time should be favorable for a bond issue. Mr. Limantour, the secretary of finance, in his report to the Mexican Congress in December, 1905, stated that in the current year the company had begun putting the bonds on the market and refunding the loan. The government was devoting the principal and interest received to the port works.

The relation of the Tehuantepec National Railway to the Panama Canal is an interesting one, yet for the present this relation is largely conjecture. It has been assumed the railway line makes a shorter traffic route for the Atlantic coast and for Europe of about 1,200 miles, while it is alleged to be a shortening of 850 miles for New Orleans traffic. But for the next few years the railway is likely to be viewed mainly as a means of taking care of the overflow traffic which can not be carried by the Panama Railroad on account of the necessity of using its facilities for the construction work of the canal.

The influence of the Tehuantepec line on the Mexican national development is an unquestionable one. Intimations are given that Mexico will now enter upon a series of trade treaties with Chile and other Pacific coast countries of South America with a view to securing not only a portion of their traffic for international transit, but also with the purpose of extending Mexican commerce. These trade arrangements have been negotiated in the past, but the lack of harbor facilities at Salina Cruz rendered them nugatory.

In connection with the Mexican national development, the Tehuantepec Railway should be considered not only as a line across the isthmus but as the basis for feeding lines. Under existing railway operations not only the port of Coatzacoalcos but the port of Vera Cruz has through railway facilities. From Vera Cruz to Salina Cruz is 285 miles as against 190 miles from Coatzacoalcos to Salina Cruz. In this view not much through traffic may be expected by way of the former route. Mexico City, however, and the country tributary to it may reap some advantage from the Pacific coast commerce *via* Salina Cruz. From the Pacific coast port to the railway junction at Santa Lucrecia is 122 miles, and from thence to Cordoba 102 miles. The distance from Cordoba to Mexico City is 198 miles, so that the capital by these routes is only 422 miles from Salina Cruz. The Vera Cruz and Pacific Railway, which, by means of the junction of two branches at the point known as Tierra Blanca, brings both the Gulf city and the capital city into communication with the Pacific coast, is owned by the government. The roadbed, however, is through a tropical country, in which the rains are very destructive to railway property, and at the present time this line, because of its poor condition, could take care of very little freight in the wet season. Steps have been taken for improving it by substituting new steel bridges for the old ones, which were unable to withstand the floods. Possibly within another year the roadbed will be reconstructed, as was done with the Tehuantepec line. Certainly, if any marked increase of commerce seems likely to develop from this line, the improvements will be made.

THE PANAMA CANAL AND THE PANAMA RAILROAD.*

By John F. Wallace.

In considering the question of alternate plans for the canal, whether it should be upon a high level with locks, or upon a sea level, without locks, my judgment as an engineer is controlled by several principles which commend themselves to me as really fundamental, and, so far as I am concerned, conclusive.

In the first place, it must be conceded that an approximately straight, sea-level canal of ample width and depth is the best type of canal, and that any other plan which places restrictions upon the probable permanency of the canal itself as well as upon the speed and the size and number of vessels passing through it, must necessarily render the canal far less valuable and far less desirable than if such doubt as to its permanency and such restrictions did not exist.

* Submitted to United States Senate Committee on Interoceanic Canals.

In the second place it must be equally admitted that the only deterrent elements in accomplishing the more desirable result, that of the sea-level canal, are the two factors of relative time and cost, when this most desirable form is contrasted with the far less desirable form of a high-level canal with locks.

In the third place it must be admitted that a very proper way to approach a discussion of the relative desirableness of these types would be to consider how much money the American people may be supposed to be willing to invest in the canal and how long they may be supposed to be willing to wait for its proper accomplishment.

After these important factors are determined, the committee ought to be able to readily decide which of the two types of canal seems to it to be the better, and to give its approval to the type it prefers.

Now, as to the cost: We have told the civilized world that the United States of America is willing to construct the Panama Canal for the benefit of the world and its commerce, including our own, and as we have voluntarily accepted this great duty, it is to be presumed that the people prefer that Congress should approach it from a broad, general, and liberal standpoint, constructing the most permanent and best possible type of canal, rather than to offer to the world an inferior type of doubtful permanency, especially as the best type of canal is one which, so far as can now be foreseen, will not have to be materially altered or enlarged and upon which our descendants may look with pride, with no occasion to regret any inefficiency or instability in the work due to our having been too careful of our money or too short-sighted in our engineering judgment.

The amount of tonnage which will pass through the canal when completed is, of course, largely a matter of conjecture, but it is certain that it will be large and ever increasing, and that considerable tonnage will be diverted from the Suez route. The phenomenal increase of tonnage passing year by year through the Suez Canal is a reasonable assurance that the continued prosperity and growth of the commerce of the world will justify the expenditure at Panama of the money required to give such commerce the best possible water-way between the two oceans. Judged by the capitalization and dividends now paid upon the stock of the Suez Canal it is apparent that the rates charged for transit through it are excessive, and on the assumption that the rates for passing through the Panama Canal will be considerably less, a very material saving will be offered to commerce if it takes the Panama route. Assuming that the present amount of tonnage through the Suez Canal of, say, ten million tons per annum would pass through the Panama Canal, even at a dollar a ton, there would be an approximate income of $10,000,000, which is sufficient to justify an expenditure of $300,000,000. As the commerce passing through it will in the near future pay the interest upon the bonds issued to construct it, without taking into consideration any indirect commercial benefits which would accrue to this country, and without considering the advantages which would be derived from the canal in the improbable event of war, it would seem that an expenditure of $300,000,000, a sum ample to construct the sea-level canal, would be abundantly justified considering the probable rapid development of foreign and domestic trade and the indirect results to be derived from this great water-way. Under these conditions the increased expense of constructing a sea-level canal ought not to weigh very heavily in deciding the question of type.

Now, as to the additional time required for a sea-level canal, it may be predicted with some certainty that upon a basis of reasonable energy and the use of proper business methods of administration, a sea-level canal can be fully completed in ten, or to be entirely safe, say twelve years, and a lock canal, even if only 60 feet above sea level, will require seven, or to be entirely safe, say nine years, on the same basis of energy and administration, a difference of only three years. I make this concession out of abundant caution; but considering that the work on the sea-level canal is plain, ordinary every-day work of digging and hauling away what is dug, I do not believe very much additional time would be required for the sea-level canal. It does not seem, therefore, that the additional time required for the sea-level canal should seriously militate against deciding upon that type.

It must also be remembered that it is quite possible to secure even increased efficiency, over that assumed to be now probable, in case the work should be handled by a single contracting firm, unhampered by governmental methods and with every incentive to expedite and complete the work at the earliest possible moment. Indeed, under such conditions it is very probable that the period suggested could be considerably reduced. Instead of one shift of ten hours, the contractor might utilize electric lights and work two shifts.

If it is not too much to hope that the committee will decline to recommend any form of canal which is not capable of being in the future transformed into a sea-level canal without undue interference with the world's traffic, and without undue additional cost, this fact alone should take the recommendations of the minority of the board of consulting engineers and the recommendations of the majority of the Isthmian Canal Commission out of really serious consideration; for it is difficult to see why any type of canal should now be authorized, the destruction of any important feature of which, either by act of God or of man, would block all use of it until its restoration, particularly when such interruption of traffic would almost certainly extend over several years, and the world having become

accustomed to its advantages would incur such a loss of time with the greatest possible sense of injury.

There is another engineering problem which ought to have careful consideration, and that is whether Congress will feel justified in indorsing the construction of any dam of large dimensions, retaining a head of water of say 85 feet, the foundation of which does not extend to bedrock or to some equally impermeable and reliable stratum. The engineering question may be thus stated: is it either safe or wise to authorize the building of a dam $1\frac{1}{2}$ miles long to retain a head of water of 85 feet across an alluvial valley, similar to the valley of the Chagres at Gatun, in which exists already two sub-surface gorges, one of which alone is 1,000 feet across and 240 feet deep, which has evidently been refilled with a heterogeneous mass of gravel, sand, sandy-clay, driftwood and the general character of detritus brought down into the valley by the mountain streams? With this situation in view it is greatly to be feared that the dam at Gatun, which is proposed by a minority of the board of consulting engineers and which is indorsed by a majority of the Isthmian Canal Commission, might after some years be found incapable of holding back so great a head of water and withstanding the strain upon it. This apprehension is greatly emphasized by the character of the borings in this locality, because they have not been sufficient to determine the accuracy of the cross section which has been submitted as one of the exhibits of the board of consulting engineers to the Isthmian Canal Commission. Sand or gravel may even underlie the indurated clay into which borings have only been made a short distance. The same remarks apply, though in a lesser degree, to the series of dams and barrages holding back a head of 55 feet of water which it is proposed by the minority report to construct across the alluvial valley of the Rio Grande on the Pacific side of the canal.

From an engineering standpoint it is difficult to understand why a much better place for the construction of a dam to control and regulate the floods of the Chagres River is not at Gamboa, where it is positively known that the primary rock foundation exists at no greater depth than sea level and where it is possible to construct a masonry dam founded on solid rock at such a moderate depth and in accordance with established methods, that its integrity will no longer give rise to question.

If, therefore, it is decided to disregard the recommendations of the majority of the board of consulting engineers, and to build a lock canal, then it is to be earnestly hoped only such form of lock canal will be authorized as will be admissible in connection with the construction of a dam at Gamboa, rather than at Gatun. While for certain purposes and under certain conditions earthen dams of large dimensions carefully formed are permissible, in this case it is not believed that such form of construction should be seriously considered when it is possible to secure a masonry structure founded on bedrock; particularly when the work under consideration must be supposed to possess permanency, and is being erected as a monument to the engineering skill of our modern civilization. There is no urgency that to my mind would justify the great risk of earth dams at Gatun or La Boca.

The next important matter to consider and decide is whether the canal shall be constructed under the present method of management or whether a contract for the work shall be made with a single contracting firm. In the latter case the specifications, of course, should be of the most broad and general nature, leaving all detail engineering plans to the engineers of the contractor in order that he may have the fullest latitude in immediately meeting and overcoming such local difficulties as from time to time are sure to arise. After the contract is let, there would, of course, be no reason for retaining a cumbersome governmental organization in reference to the work, for there is no doubt that the corps of engineers of the United States army could most efficiently supervise the contractor engaged upon the work. All the governmental functions, including policing and sanitation, could easily be performed under the control and direction of the governor of the canal zone. It cannot be doubted that these two methods, if adopted, will give entirely satisfactory results.

The question will naturally arise in doing the work by contract whether there are any engineering organizations competent to enter into such a contract and to construct a work of this magnitude, and such a question must be answered in the affirmative. Several well-known organizations are quite capable and competent to handle a work of this character, and there is no good reason why they could not be induced to make bids for it, if Congress in its wisdom decides such a method of management of this great work is preferable to that which has existed for the last two years.

In considering the question of additional time required for the construction of a sea-level canal the prompt and efficient utilization of the Panama Railroad is a matter of very great importance; for if the railroad is provided, without unnecessary delay, with the very best modern facilities and equipment, including double tracks with abundance of sidings, shops, wharves, docks, and warehouses, and especially with the latest and most approved appliances for transferring cargoes from ships to cars and from cars to ships, very many of the advantages the world's commerce would derive from the completion of the canal will be at once afforded to it. Indeed, in many cases of goods shipped from American ports destined to the west coast of South America, it will probably be found advantageous for them to go in a single ship to Colon and being transferred by the railroad to Panama, be reshipped in smaller vessels plying from that port to the different ports to which different parts of the cargo may be consigned.

There are two suggestions which since they were first made have been subjected to very careful and thoughtful review because of criticisms which have been passed upon them. The first is that the railroad should be substituted for the canal while the canal is in process of construction. If so, it should be completely separated in management and control from any steamship line at either end, as the canal itself will be, and the charge for transfer from ship to ship should be a flat rate per ton regardless of classification except that light and bulky articles should be rated at a certain number of cubic feet to the ton. This rate should not be in excess of two dollars per ton, even with the present limited amount of business, and as the business increases the rate should be reduced as the receipts justify. Of course, railroad managers who are accustomed to through bills of lading and through rates naturally desire that the railroad should be considered only a link in the shipments from one part of the world to another and that the same cumbersome classifications should prevail to which they have been accustomed in the movement of transcontinental traffic; but all such intermeddling with the transit across the isthmus will disappear as if ation. Under such a system of administration there is therefore not the slightest reason why it should not disappear now, and the world's commerce be proffered substantially the same advantages of transit across the isthmus that, under precisely the same circumstances, it will enjoy when the canal itself is placed in operation. Under such a system of adminstration there is no occasion whatever for the Panama Railroad maintaining a corporate existence with offices in New York, for the road can be far better controlled by a single competent railway manager on the isthmus, who would, of course, be under the direction and control of the general contractor in case the entire work is let under one contract.

This arrangement alone would save a large annual expenditure now apparently wasted on the Panama Railroad organization and do away with the complexities which that organization evidently produces, while at the same time the embarrassing questions arising from the alliance of steamship lines with the transit across the isthmus could be separately considered on their merits, leaving the government at liberty to retain a line of transports for its own use or rely upon the boats reaching the isthmus both from the east and the west, as the government's best interest might dictate; but, however, government transports ought not to have the slightest possible advantage over any competing line of ships.

The method thus suggested of operating the railroad as a simple transfer line across the isthmus, and, therefore, as an immediate and practicable substitute for the canal with a low flat rate or charge, common to all the world's commerce, is a practicable and simple proposition which the committee will readily understand even if it declines to approve it. Above all, it would remove at once all cause for charges of favoritism for or discrimination against any particular interest or section of our country or even between ourselves and foreign nations and thus enable the United States to redeem immediately the promise it has given that the great waterway which it is now constructing shall offer equal advantages to all the world and special privileges to none.

It must also be remembered that with such an excellent substitute for the canal while the canal is being constructed, any slight delay in construction will be of far less importance than if the present organization of the railroad in New York is maintained and its mystifying relations with through bills of lading and through rates continued.

The expenditures which will be necessary to put the railroad in condition for this important work have already been partly made and will be required in any event for the road to furnish the proper facilities for the construction of the canal so that no considerable additional expense is involved in the proposition.

As the primary reason for the construction of the canal has always been given as that of affording free and unobstructed facilities for all commerce across the isthmus, it would really seem to be our imperative duty to provide these facilities at the earliest possible moment when it can be done at a very moderate cost, and in a simple manner.

It is, of course, a fundamental practice in railroad maintenance and operation that all physical changes and improvements of railroad properties should be so conducted as not to interfere with or delay the current traffic and the same principle should apply to the construction of the canal. The railroad should be used as an instrumentality for this construction, but it should not be so used as to be injurious to the present facilities for commerce. On the contrary, it should be enlarged, improved and amplified for increasing such facilities in the manner already indicated.

If the committee should think that undue importance is being attached to this question, it may be suggested that when such a large measure of benefit to the world's commerce can be secured by the expenditure of so small a sum and in so short a time, and so great a percentage of benefit to be ultimately derived from the construction of the canal be at once secured, the importance of intelligent and immediate action by Congress can readily be understood and is earnestly urged upon it.

It must be remembered, and it is well known to persons engaged in large transportation problems, that it is much easier to retain and regulate the movement of traffic along lines to which it has been accustomed, than it is to regain it after it has been once diverted to new routes, and the committee ought not to overlook the competition of the Tehuantepec route, which is now being provided with every kind of facility for handling traffic from ship to cars, and from cars to ship across that isthmus, and which it is suggested ought to be immediately provided at Panama, so that not only the commerce now passing across the isthmus at Panama may be retained but every possible inducement offered to the constantly increasing commerce of the world to avail itself of the facilities of this route, rather than allow itself to be diverted to the Tehuantepec route on account of lack of facilities at Panama.

In conclusion, it must be admitted that the problems now confronting Congress are of a very embarrassing character, but the intelligence and patriotism of its members will surely enable it to reach satisfactory conclusions. When such conclusions are reached both as to type of canal, whether at sea level or with locks, and as to the best method of constructing it, whether under the present organization or by letting the contract to outside parties under the supervision of the corps of engineers of the United States army, it cannot be doubted that its decision will meet the expectations of the people in all respects and satisfy the just pride that their country has undertaken the task of conferring upon the world the benefits of this great enterprise.

AN AUGER FOR BORING SQUARE HOLES.

AN AUGER FOR BORING SQUARE HOLES.

As ordinary augers have a circular motion, they can, of course, be employed for drilling round holes only; but a tool which has been devised by an American house, the Square Auger Manufacturing Company, and which is illustrated herewith, is capable, through an ingenious arrangement, of boring square ones. The apparatus consists of a disk with a central point and two oblique blades and capable of being detached from the shank to the extremity of which it is fixed by a screw. The end of the socket in which the shank revolves is square and two of the opposite sides are hollowed out for the reception of two wheels with cutting teeth of which the axis is at right angles with that of the auger. These wheels consequently revolve in two parallel planes and, in their rotary motion, cut the wood in such a way as to give two parallel plane faces and form a square hole in the center of which is inscribed the circle traced by the auger. The control of these wheels is assured by a toothed wheel with which they mesh and which is itself actuated by the shank of the auger. The revolution of the cutting wheels is slightly slower than that of the auger. Since in spite of this double combination, there might remain in the mortise, between the two wheels on the sides of the auger, a little wood that had not been removed either by the wheels or the drill, the square mounting in which the wheels are housed carries on the two faces, at right angles to those in which the wheels are adjusted, a fixed knife which cuts such wood as the tool penetrates. The shank, too, is provided with a worm which receives the particles of wood that have been cut by the auger and expels them at the extremity of the socket. Naturally, when the tool is in operation it is necessary to fix the square mounting securely so that it cannot move in any direction and the hole shall be made perfectly square.—Translated from La Nature for the Scientific American Supplement.

Hair Wash.—5 parts of rose water to 1 of dilute acetic acid, and a few drops of perfume. A small quantity diluted with water will cleanse the scalp and remove dandruff.—Neueste Erfahrungen und Erfindungen.

[Concluded from SUPPLEMENT No. 1578, page 25282.]

THE PRESSURE OF EXPLOSIVES. EXPERIMENTS ON SOLID AND GASEOUS EXPLOSIVES.*

By J. E. PETAVEL.

Relation of Pressure to Gravimetric Density.

THE present work was not taken up with a view to specially investigating the above subject, which has already been fully treated by Noble. It is, however, of interest to compare the results with the much more complete set published by this investigator.

To minimize the effect of the rapid rate of cooling,

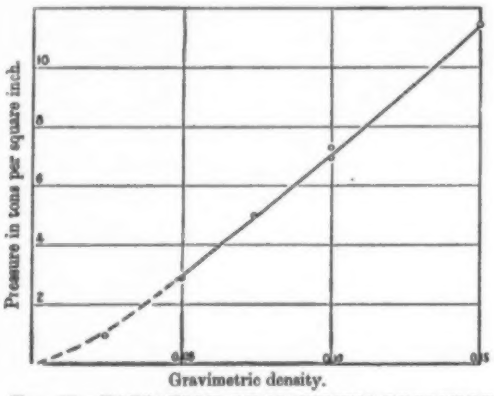


FIG. 17.—VARIATION OF MAXIMUM PRESSURE WITH THE GRAVIMETRIC DENSITY OF THE CHARGE.

The curve is traced out from the values given by Sir Andrew Noble; the points marked on it refer to the results incidentally obtained in the course of the present work.

which, as we have just seen, is inherent to small inclosures, we must select for comparison the values obtained when using cordite of relatively small diameter. The pressures obtained with cordite of 0.175 inch and 0.035 inch diameter are shown in Fig. 17, marked in on the curve representing Noble's results, and are, as will be seen, in close agreement with it.

Though the pressure and temperature are exceptionally high, there is no reason for supposing that the products of combustion depart considerably from the law which governs the pressure of gases at ordinary temperatures.

This law may be written

$$(p + a)\ (v - b) = RT.$$

In the present case, where the temperature is very high and constant, we may put $RT = c$, and for a first approximation neglect cohesion of the gas.

The formula then takes the simple form

$$p(v - b) = c.$$

The volume to which the gas will be reduced under infinite pressure may be taken as closely approaching the inverse of the density of the solid explosive. Therefore

$$b = \frac{1}{1.56} = 0.641,$$

whereas v is the inverse of the gravimetric density ρ. Thus

$$c = \frac{p}{\rho} - 0.641p.$$

To minimize the error due to cooling we will take the value of p obtained for the smallest cordite in the spherical inclosure. At a gravimetric density of 0.0744 this is 5.137 tons per square inch (see Table VI.), and therefore

$$c = \frac{5.137}{0.0744} - 0.641 \times 5.137 = 65.75.$$

The pressure developed by the explosive is

$$p = \frac{c\rho}{1 - b\rho} = \frac{65.75\rho}{1 - 0.641\rho}.$$

The results calculated from this formula are compared in the following table with Noble's values and with those obtained during the course of the present work:[1]

Gravimetric density.	Pressure calculated.	Pressure determined experimentally by NOBLE.	Pressure determined experimentally by PETAVEL.
0·05	3·40	3·00	2·87
0·10	7·03	7·10	7·01
0·15	10·91	11·36	11·48
0·20	15·08	16·00	—
0·30	24·42	26·00	—
0·40	35·37	36·53	—
0·50	48·38	48·66	—
0·60	64·10	63·33	—

In the above table the pressures are expressed in tons per square inch.

The experimental results are influenced by many factors, such as the size of the inclosure, the dimensions of the explosive, and the oscillations of pressure, which are doubtless occasionally set up. On the other hand, the formula we have used does not take into account the cohesion of the gas, or allow for the possible variation of the value b with temperature and density.

Taking these circumstances into account, the agreement between the theoretical and experimental values may be considered satisfactory.

Distribution of the Explosive.

In a long narrow vessel a certain amount of vibration almost invariably occurs during the combustion of the explosives. If the explosive is concentrated in

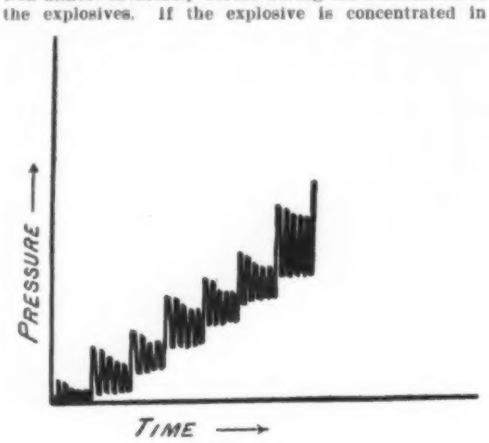


FIG. 18.

Diagram showing the type of vibration set up at the commencement of an explosion when the charge placed in a long enclosure is not uniformly distributed. The successive sharp increments of pressure correspond with successive impacts of the wave.

one part only of the inclosure, the effect is increased and the pressure rises by sharp steps, as shown in Fig. 18. With some powders the sudden increments of pressure become dangerously large and an abnormally high maximum is reached in one or two steps. This phenomenon seems to be the transition between an explosion and a detonation.

That it is difficult, in fact almost impossible, to detonate cordite has long been recognized as one of its principal advantages. Nevertheless, signs of abnormal explosion were visible whenever the charge was crowded together in one part of the inclosure. A similar effect being recorded in many other cases, notably F 68, F 69, and F 70 (Tables XI., XII., XIII.).

The experiments in this direction had to be confined to pressures of about 1,000 atmospheres. From these tests it seems probable that by working under similar conditions, but with a higher gravimetric density, cordite would give results not unlike those obtained by Vieille[2] in the case of "B.F." and other powders. Unfortunately, for this very reason, the experiments could not be carried out in a laboratory.

The sharp steps which go to make up these records may be accounted for in the following manner: When the explosive, which is packed closely at one end of the chamber, bursts into flame, a pressure wave is sent out which travels to the end of the cylinder and is then reflected back. When this wave, on its return journey, reaches the explosive, the combustion, which in the meantime had been proceeding uniformly, is accelerated in proportion to the increased pressure. The case is one of mutual reaction between the two phenomena. Any irregularity in the combustion tends to start a pressure wave which in turn enhances this irregularity. The process is cumulative in its effects, and with the high gravimetric densities used in ballistic work it may, and doubtless occasionally does, cause disastrous results.[3]

Incidentally the present work confirms Vieille's[4] views as to the discontinuity of pressure set up by wave actions, the successive steps of the curve rising abruptly, if not instantaneously.

The velocity of propagation of the wave is measured directly by the time elapsing between the successive sharp increments of pressure which are recorded.

When a wave is set up at the commencement of the explosion, the impacts on the recording gage succeed each other at intervals of 0.00125 or 0.00121 second when the charge in the cylinder is at gravimetric densities of 0.10 or 0.15 respectively. The path traversed, i. e., the double length of the inclosure, is 139.3 centimeters, and the corresponding velocities 1,114, 1,150 meters per second.[5]

Occasionally, when cordite of the smallest diameter is used, the wave motion is still sharply defined at the maximum pressure. The time interval is then 0.00110 second for a gravimetric density of 0.1, and the speed 1,266 meters per second.

From the general formula for the velocity of sound we can calculate the theoretical speed under these circumstances,

$$V = \sqrt{\frac{\gamma E}{\rho}}.$$

These factors, with the exception of γ, are well known.

When the combustion is complete, the density, ρ, of the resulting gases is equal to the gravimetric density of the charge.

The elasticity, E, is measured by the rate of change of pressure with density.

$$E = \rho \frac{dp}{d\rho}.$$

It can, therefore, be obtained by differentiating the expression

$$p = \frac{\rho c}{1 - \rho b}$$

Carrying out this operation we find

$$E = p\left(1 + \frac{pb}{c}\right).$$

The value of the ratio of the specific heats, γ, is somewhat uncertain. For the mixture of gases resulting from the explosion, γ may be taken as 1.35 or 1.21, according as the specific heats are considered constant or variable with temperature.

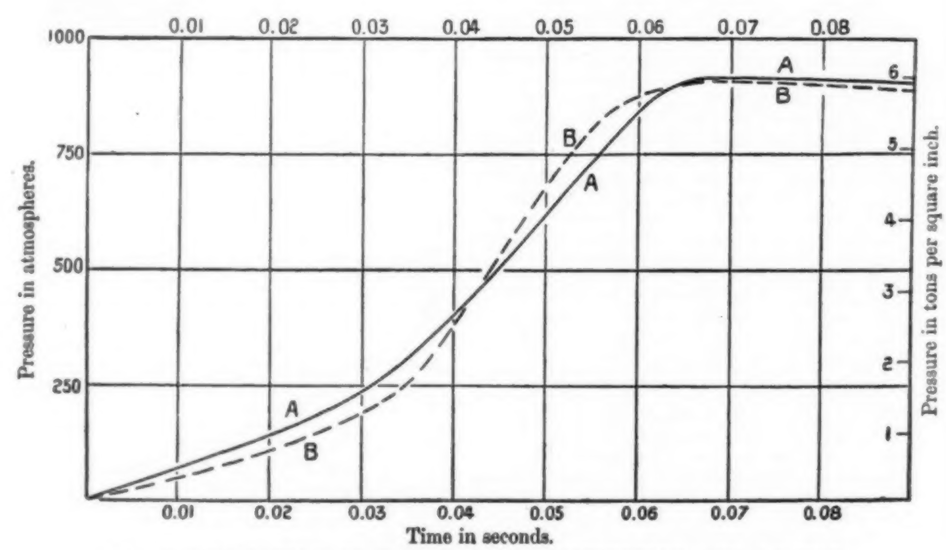


FIG. 19.—VARIATION OF THE RATE OF COMBUSTION AND OF THE MAXIMUM PRESSURE PRODUCED BY A NON-UNIFORM DISTRIBUTION OF THE CHARGE.

Cylindrical inclosure; gravimetric density 0.1; diameter of cord 0.475 inch (12.07 millimeters). *A*, charge uniformly distributed; *B*, charge placed in one-sixth of the cylinder near the recorder.

The following table gives the velocity of sound, calculated according to each of the above hypotheses:

Velocity of Sound in the Gases Produced by the Combustion of Cordite at the Maximum Pressure of the Explosion, Measured in Meters per Second.

Gravimetric density.	Velocity for = 1·35.	Velocity for = 1·21.
0·1	1251	1185
0·2	1343	1272
0·3	1450	1373
0·4	1575	1491
0·5	1723	1632
0·6	1903	1801

*Philosophical Transactions of the Royal Society of London.

[1] When the pressure is measured in kilogrammes per square centimeter the constant c becomes 10355, whereas $c = 10021$ gives the pressure in atmospheres, the constant b in either case remaining unaltered. A formula similar to the above was used by Noble and Abel in connection with their researches on fired gunpowder. They assumed that the gases strictly followed Boyle's law, but introduced a factor $(1 - \alpha\beta)$ to allow for the space occupied by the solid residues left after the explosion.

[2] See "Etude des Pressions Ondulatoires," Annales des Poudres et Salpètres, vol. iii., pp. 177-236. Vieille, in the course of this work, obtained instantaneous pressures amounting to three times the normal value. Using a method of calculation similar to that given below, he showed that the speed of propagation of the smaller disturbance is in fair agreement with the speed of sound in the same medium.

[3] See Cornish, Proc. Inst. Civ. Eng., vol. 144, p. 241, 1901.

[4] Mémorial des Poudres et Salpètres, vol. 10, pp. 177-260, 1899-1900.

[5] Theoretically the speed should be the same in either case; the thermal loss, which is relatively less at higher gravimetric densities, probably accounts for the difference.

The limiting value for low densities, which should correspond with the speed of the wave at the commencement of the explosion, works out at 1,170 ($\gamma = 1.35$) or 1,108 ($\gamma = 1.21$).

Although, strictly speaking, the above theory applies only to very small disturbances, the calculated velocities are in fair agreement with the measurements given above.

The oscillations referred to in the preceding paragraph are superimposed on the curve of pressure without directly altering its general shape. Within the limits of the present experiments the wave action, consequent on the uneven distribution of the charge, by increasing the thermal loss slightly lowers the maximum pressure. The rate of combustion is, also, somewhat altered; usually it is accelerated.

These effects will be best understood by reference to Figs. 14, 19, and 20, in which the mean values of the pressure are plotted in terms of the time.

Generally speaking, the results obtained confirm the remarkable properties of cordite with regard to its high power and to the regularity of the effects produced. It would doubtless be very desirable to extend the research to higher pressures and carry out, on similar lines, a comparative study of other explosives. Treated, however, in this general way, the subject is too vast to be dealt with single-handed, and the writer can but express a hope that others more competent and better equipped will be found willing to take up the work.

Before closing I desire to thank Prof. Arthur Schuster for placing at my disposal the ample resources of his laboratory.

The cost of the apparatus has to a large extent been defrayed by funds awarded by the Government Grant Committee of the Royal Society, while for the cordite I am indebted to the courtesy of the War Office authorities.

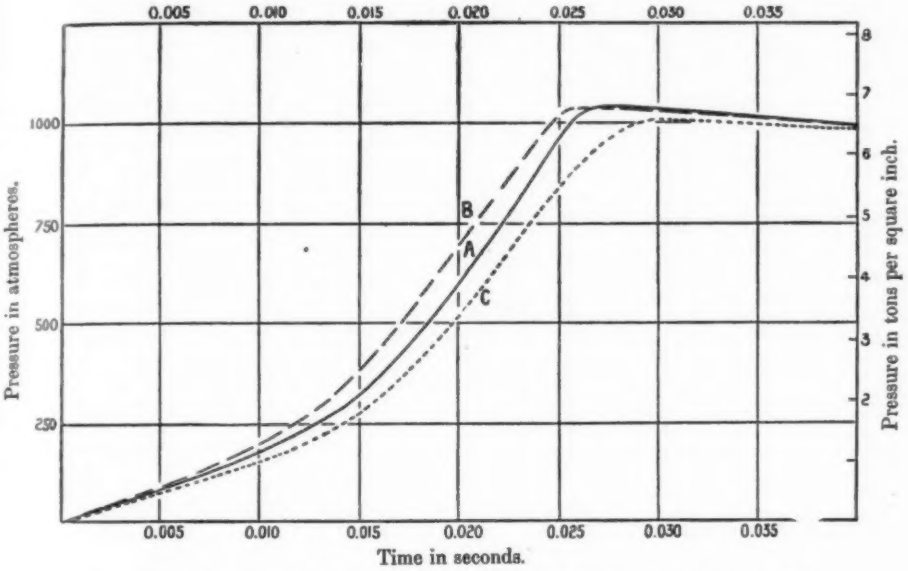


Fig. 20.—VARIATION OF THE RATE OF COMBUSTION AND OF THE MAXIMUM PRESSURE PRODUCED BY A NON-UNIFORM DISTRIBUTION OF THE CHARGE.

Cylindrical inclosure; gravimetric density 0.1; diameter of cord 0.175 inch (4.44 millimeters). *A*, charge uniformly distributed; *B*, charge placed in one-half of the cylinder farthest from the recorder; *C*, charge placed in one-sixth of the cylinder farthest from the recorder. This case is somewhat exceptional. The charge was so closely packed that it formed a nearly solid mass, which was probably scattered on ignition by the pressure of the gas produced behind it.

APPENDIX.

In the following tables numerical results obtained from the measurements of the principal photographic records will be found.

Where wave action is set up, the pressure given is the mean value of the instantaneous pressure at the time indicated.

Table I.—(Record No. F 55.)

Spherical explosion vessel; charge uniformly distributed; gravimetric density 0.0496; diameter of cord 0.475 inch (12.07 millimeters).

Maximum pressure 404 atmospheres (2.65 tons per square inch); time required to reach the maximum pressure 0.120 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·010	10	0·130	404
0·020	22	0·200	397
0·030	31		
0·040	43		
0·050	67		
0·060	98		
0·070	190		
0·080	215		
0·090	287		
0·100	353		
0·110	397		
0·120	404		

Table II.—(Record No. F 56.)

Spherical explosion vessel; charge uniformly distributed; gravimetric density 0.0496; diameter of cord 0.175 inch (4.44 millimeters).

Maximum pressure 438 atmospheres (2.87 tons per square inch); time required to reach the maximum pressure 0.045 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·005	24	0·100	436
0·010	48	0·200	421
0·015	88	0·300	390
0·020	131	0·400	364
0·025	187	0·500	339
0·030	271		
0·035	363		
0·040	433		
0·045	438		
0·050	436		

Table III.—(Record No. F 57.)

Spherical explosion vessel; charge uniformly distributed; gravimetric density 0.024; diameter of cord 0.035 inch (0.89 millimeter).

Maximum pressure 144 atmospheres (0.95 ton per square inch); time required to reach the maximum pressure 0.014 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·002	12	0·020	144
0·004	28	0·050	143
0·006	53	0·100	141
0·008	77		
0·010	103		
0·012	127		
0·014	144		

Table IV.—(Record No. F 59.)

Spherical explosion vessel; charge uniformly distributed; gravimetric density 0.099; diameter of cord 0.475 inch (12.07 millimeters).

Maximum pressure 1069 atmospheres (7.01 tons per square inch); time required to reach the maximum pressure 0.065 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·005	10	0·070	1069
0·010	34	0·100	1062
0·015	53	0·200	958
0·020	79	0·300	935
0·025	113	0·400	888
0·030	160	0·500	849
0·035	244	0·600	806
0·040	357	0·700	773
0·045	521	0·800	746
0·050	694	0·900	716
0·055	880	1·000	688
0·060	1064		
0·065	1069		

Table V.—(Record No. F 60.)

Spherical explosion vessel; charge uniformly distributed; gravimetric density 0.099; diameter of cord 0.175 inch (4.44 millimeters).

Maximum pressure 1115 atmospheres (7.31 tons per square inch); time required to reach the maximum pressure 0.022 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·002	29	0·024	1112
0·004	59	0·030	1109
0·006	102	0·100	1063
0·008	150	0·200	986
0·010	229	0·300	937
0·012	370	0·400	874
0·014	522	0·500	821
0·016	784		
0·018	971		
0·020	1089		
0·022	1115		

Table VI.—(Record No. F 61.)

Spherical explosion vessel; charge uniformly distributed; gravimetric density 0.0744; diameter of cord 0.035 inch (0.89 millimeter).

Maximum pressure 783 atmospheres (5.137 tons per square inch); time required to reach the maximum pressure 0.008 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·001	33	0·010	783
0·002	85	0·015	783
0·003	209	0·020	772
0·004	381	0·050	769
0·005	615	0·100	728
0·006	763	0·200	669
0·007	774	0·300	622
0·008	783	0·400	567

Table VII.—(Record No. F 63.)

Cylindrical explosion vessel; charge uniformly distributed; gravimetric density 0.1004; diameter of cord 0.475 inch (12.07 millimeters); temperature 18.6 deg. C.

Maximum pressure 916 atmospheres (6.01 tons per square inch); time required to reach the maximum pressure 0.070 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·010	76	0·075	916
0·020	139	0·080	916
0·030	231	0·090	892
0·040	400	0·100	868
0·050	618	0·200	694
0·060	843	0·300	563
0·065	909	0·400	453
0·070	916	0·500	397
		0·600	331
		0·700	291
		0·800	255
		0·900	225
		1·000	199

Table VIII.—(Record No. F 65.)

Cylindrical explosion vessel; charge uniformly distributed; gravimetric density 0.1004; diameter of cord 0.175 inch (4.44 millimeters); temperature 18 deg. C.

Maximum pressure 1041 atmospheres (6.83 tons per square inch); time required to reach the maximum pressure 0.028 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·005	66	0·030	1031
0·010	192	0·035	1006
0·015	396	0·040	992
0·020	679	0·050	969
0·025	939	0·060	936
0·028	1041	0·070	909
		0·080	879
		0·090	860
		0·100	828
		0·200	648
		0·300	518
		0·400	433
		0·500	347
		0·600	298
		0·700	265
		0·800	235

Table IX.—(Record No. F 66.)

Cylindrical explosion vessel; charge uniformly distributed; gravimetric density 0.0753; diameter of cord 0.035 inch (0.89 millimeter); temperature 19.0 deg. C.

Maximum pressure 793 atmospheres (5.20 tons per square inch); time required to reach the maximum pressure 0.007 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·001	26	0·008	787
0·002	102	0·009	783
0·003	195	0·010	777
0·004	324	0·015	760
0·005	453	0·020	750
0·006	658	0·025	721
0·007	793	0·030	701
		0·050	658
		0·100	630
		0·150	496
		0·200	390
		0·300	281
		0·400	212
		0·500	179
		0·600	152

Table X.—(Record No. F 67.)

Cylindrical explosion vessel; charge all in half of cylinder farthest from the recorder; gravimetric density 0.1004; diameter of cord 0.175 inch (4.44 millimeters); temperature 19 deg. C.

Maximum pressure 1035 atmospheres (6.79 tons per square inch); time required to reach the maximum pressure 0.026 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·002	33	0·028	1031
0·004	68	0·030	1026
0·006	93	0·032	1018
0·008	152	0·034	1015
0·010	188	0·040	993
0·012	246	0·050	969
0·014	317	0·060	935
0·016	430	0·100	826
0·018	549	0·200	654
0·020	696	0·300	539
0·022	853	0·400	456
0·024	955	0·500	387
0·026	1035	0·600	340
		0·700	298
		0·800	258
		0·900	233

Table XI.—(Record No. F 68).

Cylindrical explosion vessel; charge all in one-sixth of cylinder farthest from the recorder; gravimetric density 1.004; diameter of cord 0.175 inch (4.44 millimeters); temperature 18.6 deg. C.

Maximum pressure 1002 atmospheres (6.57 tons per square inch); time required to reach the maximum pressure 0.030 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·002	33	0·032	1002
0·004	60	0·034	995
0·006	86	0·040	955
0·008	106	0·050	942
0·010	149	0·060	919
0·012	179	0·100	830
0·014	241	0·200	631
0·016	307	0·300	522
0·018	387	0·400	433
0·020	509	0·500	337
0·022	646	0·600	281
0·024	777		
0·026	879		
0·028	975		
0·030	1002		

Table XII.—(Record No. F 69.)

Cylindrical explosion vessel; charge all in one-sixth of cylinder near the recorder; gravimetric density 0.1004; diameter of cord 0.475 inch (12.07 millimeters); temperature 18 deg. C.

Maximum pressure 906 atmospheres (5.94 tons per square inch); time required to reach the maximum pressure 0.70 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·010	48	0·075	906
0·015	73	0·080	898
0·020	106	0·090	889
0·025	146	0·100	880
0·030	199	0·200	671
0·035	235	0·300	583
0·040	374	0·400	486
0·045	530	0·500	384
0·050	678		
0·055	807		
0·060	879		
0·065	900		
0·070	906		

Table XIII.—(Record No. F 70.)

Cylindrical explosion vessel; charge all in one quarter of cylinder near the recorder; gravimetric density 0.0753; diameter of cord 0.035 inch (0.89 millimeter); temperature 17.0 deg. C.

Maximum pressure 764 atmospheres (5.01 tons per square inch); time required to reach the maximum pressure 0.007 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·001	76	0·008	760
0·002	162	0·010	754
0·003	241	0·015	727
0·004	417	0·020	694
0·005	548	0·030	661
0·006	724	0·040	628
0·007	764	0·050	595
		0·100	460
		0·200	367
		0·300	308
		0·400	212
		0·500	175

Table XIV.—(Record No. F 71.)

Cylindrical explosion vessel; charge uniformly distributed; gravimetric density 0.1004; diameter of cord 0.175 inch (4.45 millimeters); temperature 17.5 deg. C.

Maximum pressure 1058 atmospheres (6.94 tons per square inch); time required to reach the maximum pressure 0.028 second; charge fired with 2 grammes of fine granulated powder.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·002	26	0·030	1058
0·004	48	0·040	1051
0·006	83	0·050	1026
0·008	126	0·060	996
0·010	162	0·100	893
0·012	223	0·200	737
0·014	291	0·300	612
0·016	417	0·400	503
0·018	545	0·500	413
0·020	609	0·600	331
0·022	843	0·700	291
0·024	975	0·800	248
0·026	1038		
0·028	1058		
0·030	1058		

Table XV.—(Record No. F 72.)

Cylindrical explosion vessel; charge uniformly distributed; gravimetric density 0.1004; diameter of cord 0.035 inch (0.89 millimeter); temperature 17.7 deg. C.

Maximum pressure 1124 atmospheres (7.37 tons per square inch); time required to reach the maximum pressure 0.0050 second; charge fired with 2 grammes of fine granulated powder.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·001	288	0·006	1124
0·002	519	0·007	1107
0·003	807	0·010	1101
0·004	1026	0·015	1071
0·005	1124	0·020	1024
		0·030	992
		0·040	959
		0·050	925
		0·100	810
		0·200	645
		0·300	529
		0·400	430
		0·500	363
		0·600	324
		0·700	281
		0·800	246

Table XVI.—(Record No. F 73.)

Cylindrical explosion vessel; charge uniformly distributed; gravimetric density 0.1505; diameter of cord 0.475 inch (12.07 millimeters); temperature 18 deg. C.

Maximum pressure 1633 atmospheres (10.71 tons per square inch); time required to reach the maximum pressure 0.058 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·010	26	0·060	1633
0·020	76	0·065	1631
0·025	126	0·070	1587
0·030	244	0·080	1547
0·032	311	0·090	1504
0·034	412	0·100	1461
0·036	558	0·150	1323
0·038	685	0·200	1207
0·040	793	0·300	1051
0·042	1018	0·400	926
0·044	1176	0·500	842
0·046	1330	0·600	767
0·048	1451	0·700	690
0·050	1554	0·800	626
0·052	1603	0·900	579
0·054	1630		
0·056	1627		
0·058	1633		

Table XVII.—(Record No. F 74.)

Cylindrical explosion vessel; charge uniformly distributed; gravimetric density 0.1505; diameter of cord 0.175 inch (4.44 millimeters); temperature 17.6 deg. C.

Maximum pressure 1749 atmospheres (11.48 tons per square inch); time required to reach the maximum pressure 0.023 second.

Time in seconds.	Pressure in atmospheres.	Time in seconds.	Pressure in atmospheres.
0·002	33	0·025	1749
0·004	76	0·030	1742
0·006	99	0·035	1719
0·008	188	0·040	1692
0·010	235	0·050	1646
0·012	354	0·060	1610
0·014	545	0·070	1564
0·016	838	0·080	1527
0·018	1280	0·090	1494
0·020	1507	0·100	1455
0·022	1732	0·150	1316
0·023	1749	0·200	1197
0·024	1749	0·300	1041
		0·400	928
		0·500	853
		0·600	767
		0·700	701

SOME NOTES ON FUEL BRIQUETTING IN AMERICA.*

By Clarence M. Barber.

America has always been, and is now, favored above almost every other country on the globe in the supply of fuel. In no other land is it so abundant, of so good a quality or so varied in kind. Our extensive fields of bituminous and anthracite coal have been developed beyond those of any other country, and we have yet untouched great fields of baser fuel in the shape of lignite and peat, some of which are quite important on account of geographical location. The forests, once of first importance, are no longer a factor to be used in estimating the fuel resources of our country. The annual supply of coal in this country has been increased enormously within the past decade. In 1895, it was 193,000,000 tons. Our production in 1904 was 352,000,000 tons and estimates indicate that 1905 statistics will show that we have mined over 1,000,000 tons per day. But the consumption has also increased beyond what any one could have reasonably anticipated. That this wonderful production only just meets the constantly increasing demand is shown by the fact that the price to the consumer does not diminish, but rather tends to increase each year. Of this great quantity, only about 21 per cent is anthracite. To the remaining 79 per cent is chargeable the dark gloom that hangs over so many of our homes and factories.

Briquetted Fuel in Europe.

The American traveler in Europe notes with interest the use there of briquetted fuels. Coal briquettes are in large piles at the railroad coaling stations and are seen in use, more or less, everywhere, but especially in Germany, Austria-Hungary, Belgium, France, and England.

Our United States consul-general, Frank Mason, in his reports states that "briquettes form the principal domestic fuel of Berlin and of the cities and districts in Germany. They are used for locomotive and other steam firing and are employed for heating in various processes of manufacture. For all these uses they have three tangible advantages. They are clean, convenient to handle, light easily and quickly, and burn with a clear, intense flame. They make practically no smoke and are, withal, the cheapest form of fuel for most purposes."

At another point in his report Mr. Mason says: "Berlin, although a busy manufacturing city, ranks as one of the cleanest and best cities in Europe. One of the first things usually noticed by American and English travelers visiting the German capital for the first time, is the absence of that cloud of dusty smoke that overhangs so many towns and cities in our country."

Recently, and especially within the last ten years, considerable advancement has been made in this country in the way of introducing coke and gas as domestic fuel in cities. Coke from by-product coke ovens has been so favorably received that the prospect for the more extended use of this cleaner fuel is very encouraging.

Fuel briquettes are not made, or in use, in this country, except to a very limited extent and only very recently. Mr. Robert Schorr, at San Francisco, has recently installed a successful plant. Some peat briquettes are successfully made in Canada. There are some other briquetting plants, but those that have come to our notice are yet in the experimental stage.

In Germany alone the annual production is 13,000,000 tons. France produces over 3,000,000 tons and other countries bring the world's production up to over 25,000,000 tons.

Materials for Briquettes.

Briquetted coke breeze makes a very superior and clean fuel, and almost smokeless briquettes can also be made from anthracite culm and bituminous slack, as well as also from lignite and peat.

Fuel briquettes may be made from almost any combustible substance. Some materials, such as lignite and peat, can be formed into briquettes by pressure alone in a suitable press, but most materials require the addition of some adhesive substance as a binder. There is hardly a vegetable, animal or mineral carbonaceous material that can be thought of, that some one has not attempted to raise to a marketable value by briquetting, and, as usually the substance is a refuse, the financial gain, if it can be briquetted successfully, suggests at once an attractive investment for capital.

* Read before the Detroit Engineering Society.

Methods of Manufacture.

In general, it may be said that the materials that have been most successfully briquetted for fuel are bituminous slack, anthracite culm, coke breeze, lignite, and peat. Each of these substances requires different treatment on account of its different properties. They cannot be worked in precisely the same manner.

Some materials require more or a different binder than others, or none. Generally the moisture must be reduced by drying, but lignite works well with 17 per cent of moisture. Again, great or little pressure may be required, etc.

If we take as an example anthracite culm, the process of briquetting, without going sharply into detail, may be as follows: In the first place, to prepare for briquetting, part or all of the following operations may be necessary: Washing, drying, crushing, or screening. The first is necessary if the ash is too high and the last is almost always necessary to prevent foreign substances from injuring the machinery.

The prepared culm is ready to be combined with the pitch, which has been previously cracked or crushed to 0.5 inch and under. It is also not unusual to add a third element, such as a small percentage of bituminous coking coal. The ingredients are proportioned by some form of a measuring device such as three screw conveyors, or better, a Trump measuring machine. The carefully predetermined proportions are accurately measured dry, and the mixture is now spouted to a disintegrator or mill, where it is reduced to the proper fineness and thoroughly blended. The pulverized material is now passed to what is called the kneader, where the superheated steam melts the pitch and revolving blades stir the mixture which has now become a hot paste. It is next forced into molds, pressed and ejected therefrom, usually upon some form of a conveyor.

The hot briquettes become hard as the pitch cools and after a few minutes on the slowly moving conveyor they may be loaded into cars for shipment. There is a so-called wet process, which differs from the above only in the manner of introducing the pitch. The pulverized coal having been thoroughly dried, is heated and stirred by moving blades, while the melted pitch is mixed with it. The resulting paste is then molded as above.

There are many other processes, but those used for bituminous and anthracite coals or coke breeze differ from the above chiefly in the kind of binder or the type of press used.

Binders.

Coal-tar pitch is used more extensively than any other binder; in fact, we understand that in Europe the market for coal-tar pitch is supported by the demand for that product in the manufacture of fuel briquettes.

Within the last few years the supply of pitch has been greatly augmented by that obtained from by-product coke ovens. This fact alone has given the briquetting industry in Europe great assistance, and the lower price of pitch from the same cause in this country is a new inducement for the development of the enterprise here.

Owing to the fact that the cost of pitch has been an important factor in the expense of producing briquettes, many other materials have been tested with varying results. Asphalt pitch is quite successfully used. Sago flour is used with a very small quantity of pitch by an English firm, with, it is claimed, a satisfactory result. A low grade of molasses obtained from sugar factories, and a mucilaginous liquor obtained from paper mills, have also been used. Rosin is used to some extent. Quite a number of inorganic substances are also on the list of binders. These contain more or less ash, and are, therefore, undesirable.

Practically all other binders have lost in importance in proportion as good coal-tar pitch has been reduced in price. It is acknowledged to be the best binder. Its points of advantage are chiefly: that it is a strong adhesive which sets quickly on cooling; that it contains practically no ash, so that the briquettes show rather less ash than the materials which it binds together; that it protects the briquettes against hygrometric changes, so that they will not suffer when exposed in wet or freezing weather; and further, that on account of its high calorific value, it increases the thermal units in the briquettes above that of the other ingredients.

Its points of disadvantage are its cost and the fact that when used in considerable quantity it causes a slight smoke when the fire is being started or when a fresh charge is added. The smoke is very thin and light and lasts but a few moments. It is reduced to a minimum when the quantity of pitch is small, and if the furnace has a suitable draft it may not be observable at all.

Pitch.

Coal-tar pitch, as all doubtless know, is obtained from coal tar by distilling off part of the volatile oils. The pitch may be soft or hard according to the amount of the volatile oils remaining when the distillation is stopped. If continued until all the volatile oil is removed, then there will remain simply a dry fixed carbon or coke. The value of pitch as a binder for the manufacture of briquettes depends chiefly upon the proportions of oil and fixed carbon the specimen contains. This point was established by a careful series of tests made at the coal testing plant of the United States Geological Survey at the Louisiana Purchase Exposition.

The softer specimens of pitch, such as those used for pavements, melting at about 25 deg. C. and the roofing

pitch, melting at 38 deg. C., must be shipped in barrels, as they often flow like wax at summer heat or from the heat absorbed from direct sunlight even in cool weather. The harder specimens, or those which melt above about 55 deg. C., can be handled in bulk or in sacks, and do not require barrels if kept shaded from the sun. This matter is quite important as an element of the cost of pitch. A saving of between $2 and $3 per ton is effected if the pitch does not require to be shipped in barrels.

Both soft and hard pitch are used for the manufacture of briquettes, but we note that most European manufacturers are using rather hard pitch.

Briquetting Presses.

That part of the machinery of a briquetting plant which is used for handling the material, crushing, screening, elevating into bins, measuring and mixing the ingredients, etc., is all such as may be seen at work elsewhere in this country. The press used for briquetting, while it is often very similar to our brick-making machines, is really the only special machine required. It is also the most expensive and important. The press must be adapted to the kind of material to be worked, to the size and shape of the briquettes desired, as well as to the quantity to be produced in a unit of time.

In Europe, where the industry has been developing for the last forty years and more, the press question has been pretty well exploited, if we may judge from the number of different kinds of presses that are in use and offered for sale by manufacturers.

In general, the presses are divided into classes according to their mechanical design. I will note a few of the more important classes.

Open-Mold Presses.

Open-mold presses are those in which the material is forced through a tube-shaped mold by a reciprocating plunger or a screw. The continuous column delivered from the tubular mold is usually cut by wires to the desired length of the briquettes. Sometimes the reciprocating plunger produces a briquette at every stroke, each being formed against the preceding one, the tube being long enough to contain several briquettes. In this case the column issuing from the mold being composed of separate briquettes does not require to be wire cut, as the briquettes fall apart as they issue from the mold. The resistance against which the plunger or screw acts in this case is the friction of the material against the sides of the mold. Open-mold presses are used in this country for wire-cut brick, and those of the reciprocating plunger kind are worked not far from Detroit on peat, for which they are well adapted. It is evident that the consistency of the material used in these presses must be carefully gaged, as the density of the briquettes and the pressure will depend on the viscosity of the material fed to the press.

Closed-Mold Presses.

Of these there are a large number. There are single-plunger presses, in which the material is filled into a mold and pressed by a single plunger against a solid resistance, which may be a plate covering the opposite end of the mold. This press is successfully worked on lignite, but it is not generally adopted for other coal.

The double-plunger press is simply a mold with a pair of opposing plungers. In this press the material receives pressure on both ends at once. Where heavy pressures are required, and especially on large briquettes, foreign engineers recommend this press.

Most of the larger briquette factories of Europe use some form of the double-plunger press. In the Couffinhal type, which is one of the most successful in use, there is a large disk, usually about 54 inches in diameter and about 5 inches thick. This disk revolves in a horizontal plane. The molds, usually eight in number, are simply holes cut through the disk. The material is filled into the molds and receives pressure from below and above at the same time by a pair of vertical plungers which usually give a pressure of about 2,000 pounds per square inch. After each stroke and when the plungers are withdrawn, the disk revolves far enough to bring another mold under the plungers, and the already pressed briquette is moved under an ejecting plunger and forced out upon a conveyor. Presses of this type, working on large briquettes, produce as high as fifteen tons or over per hour. When working on small briquettes the production falls as low as two tons per hour and under.

Another type of the closed-mold press is that which has been known as the eggette press of Belgium. This machine has two tangent cylinders whose axes are parallel. The cylinders roll together and the eggettes are formed in the semi-egg-shaped depressions which cover the surfaces of the cylinders.

This eggette machine is quite largely used. It has the advantage of yielding a rather large production, usually about five tons per hour. Its disadvantages are, that it requires more power than almost any other machine; it is difficult to keep in good running order and it is necessary to adjust the mixture of material to suit the machine rather than for any other conditions. Furthermore, there is more or less material wasted.

Size of Briquettes.

It may be noted that the machines producing the larger briquettes usually yield them at a somewhat lower cost than those producing the smaller sizes. This accounts for the fact that some consumers break up the larger briquettes for domestic use. In America, however, the domestic trade demands small briquettes. There seems to be a tendency also in Europe at present toward the smaller sizes.

For shipment and use in steamboats, where economy of space is of the first consideration, large rectangular briquettes are used because of the quantity that can be piled in a given space. A common briquette in France for this purpose is one weighing 10 kilogrammes or 22 pounds. Briquettes measuring 7 by 4 by 4.75 inches, and weighing 2 kilogrammes 500 grammes, or 5.5 pounds, are now used for ocean shipment and also for locomotive use. Rectangular briquettes from these sizes down to less than one pound each, and eggettes weighing a few ounces, are common for domestic use.

Briquettes of every conceivable solid figure have been made.

It is important to note that good briquettes may be stored out of doors for years without suffering any deterioration. Spontaneous combustion in large piles is said to be impossible.

So important are the considerations of economy of space and safety of storage, together with some other advantages, that we are told the very best coal is sometimes ground up and briquetted for the bunkers of steamships.

Conclusion.

In the matter of introducing the briquetting of fuel into this country, it is but natural to regard it as simply a transplanting of a foreign industry from European into American soil, but it seems to be much more than this. Quite a number of attempts at starting the industry here have failed. The writer examined, quite carefully, into the causes of some of these failures and obtained some valuable information.

In regard to cost of manufacture we note that Mr. Robert Schorr, of San Francisco, in his valuable paper in the Transactions of the American Institute of Mining Engineers, February, 1904, gives the cost per ton of briquettes in western America, as follows:

Labor, exclusive of stacking	$0.16
Oil and grease	.006
Sundry stores	.01
Steam fuel	.04
Interest and depreciation	.05
Total	$0.266

The total of these figures coincides so closely with the writer's own estimates that we believe them to be sufficiently correct for approximate estimates near any large city.

In regard to the cost of pitch we have not been able to obtain close figures, but we believe this item may be estimated for the Eastern or Middle States at about $7.50 per ton, or an 8 per cent mixture would give for the briquettes per ton $0.60. This gives a total, exclusive of the cost of anthracite culm, slack coal or coke breeze, of $0.87 per ton of briquettes.

If the cost of anthracite culm, for example, is taken at $0.50 per ton, and 67 per cent is used, this item would give $0.33 per ton of briquettes. If also we add to this 25 per cent of slack coal at $1.60 per ton, we should have for this item $0.40. This would give a grand total for the cost of anthracite briquettes $1.60 per ton.

In regard to the selling price of briquettes there are no figures at hand for this country. It is estimated, however, that they will command a price between the best bituminous and anthracite coals.

In regard to the proper location for a briquette plant, of course, this depends on the location of a supply of the material to be used and of the market. At the anthracite mines there is sufficient culm to last several briquetting factories for many years.

Many other places there are where, on account of coke plants and large coal distributing points, coke breeze and slack coal are to be had. Some of these places are at long distances from the mines and have an advantage on freight for a higher selling price. Lignite and peat are important sources for the future briquetting industry in America.

HOW FILLED CAPSULES ARE MADE.*

By F. F. ROBIN.

THE manufacture of filled capsules in the United States has made such rapid progress during the past few years that it is no longer a simple process, but, on the contrary, requires for success complicated and expensive machinery. Although the capsule was invented by a Frenchman, the pharmacist, M. A. Mothes, in 1833, the present manufacturing process has been largely perfected by Americans. The year 1836 saw the start of the industry in that country and it was not until 1863 that empty capsules were turned out in quantity. In the old days the work was done entirely by hand. During the years between 1875 and 1877 great strides were made in the process and several ingenious machines invented, and to-day the modern mechanical process of production has been perfected remarkably.

Machinery and Plant.—The present-day capsule plant of minimum capacity requires expensive machinery, consisting of a press with a capacity of one hundred and fifty tons pressure on the surface of the die or mold, steel-tinned plates, racks, steam kettles, a hot-water bath, a steam table, metal molds of different sizes, oval or round, a steam closet, and a machine for making gelatin leaves. The amount of floor space required for such an equipment is, however, not large, although it is capable of turning out twenty thousand capsules a day. A room 20 by 20 feet is large enough for all purposes, more especially as certain of the fixtures must of necessity be placed near together.

* Canadian Pharmaceutical Journal.

The steam closet is built into one corner of the room and fitted with a steam coil near the floor. The upper portion of the closet is fitted with shelves, or rather supports, on the side walls, which receive the drying plates like shelves. These are upheld by pieces of iron piping which are put across the front and back of the closet with about four inches of space between them. The steel-tinned plates, as well as all other utensils which are to hold gelatin, are given a coat of mercury to prevent the gelatin from adhering to them. The press, it will be seen, is put near the closet with the steam table directly in front of it and the kettles and water bath are placed near by so that the capsule maker can watch the preparation of his gelatin mass while molding capsules.

Ingredients and Process.—The modern process of manufacture may be divided into four distinct steps for the sake of description. These may be termed the preparation of the gelatin mass, the making of gelatin leaves, the drying of these leaves and the actual molding of the capsules.

Hard French pearls are made with a compound of gelatin, acacia, sugar, glycerin, and glucose, while the soft elastic capsules are made with a compound of gelatin, glycerin, and a small percentage of acacia. The latter is first dissolved in cold water and then the gelatin is added and left to soak over night. In the morning the gelatin is dissolved with gentle heat and the rest of the ingredients added. The whole mixture is then boiled for about two hours to give it tenacity and to evaporate the excess of water. Next it is run through a fine sieve into mercury-coated pans, from which it can be removed with ease when it has cooled.

To mold capsules by pression it is necessary to run the gelatin mass into leaves of a thickness varying with the size of the capsule to be made. This is done by dissolving the gelatin mass in a hot water bath fitted with a spigot at the bottom. When the material has cooled sufficiently the hot water bath is put on the gelatin leaf machine. This mechanism is simply an arrangement of two pieces of angle cast steel set far enough apart to allow the plates to be run freely between them. A knife or scraper is fitted on one end which can be raised or lowered at the pleasure of the capsule maker by two screws at any desired speed so as to produce sheets of the particular thickness required. The gelatin is run in a stream large enough to feed freely and the plates are pushed one after another past the scraper, which spreads the gelatin on them in sheets of a uniform thickness. An attendant takes the plates off the machine at the other end and deposits them on wooden racks to cool. In a few minutes the gelatin has set and can be carried into the steam chest.

Drying Gelatine Leaves.—The drying of the gelatin leaves is the third process, one of the most important. Great care must be exercised, as a little too much heat will liquefy the gelatin on the plates and cause it to run off. The sheets will then become too thin and so be worthless. The usual method of governing this delicate process is to have the steam valve in the closet itself so that the heat can be regulated at will. There is no set rule by which gelatin can be dried, for, as it will absorb moisture very quickly, every change in the atmosphere will make necessary a change in the drying process. If the sheets are not dry enough when the capsules are molded they will not form at all or many will be found leaking.

When the gelatin leaves have dried sufficiently they are taken out of the closet and about forty plates are left in the closet for immediate use. The room is then heated to a temperature of about 80 deg. F., and the liquid to be encapsuled, as well as the mold, is kept lukewarm. Two plates are brought out of the closet and the sheets stripped off. One sheet is put on the lower part of the mold and the liquid poured in the depression made by the collar; the other sheet is put on top of the liquid. Air is excluded from between the sheets, the top part of the mold is fitted on, and the whole mold put in the press. Pressure is then quickly applied and in a few seconds from one to three hundred capsules are made.

The Actual Molding.—It is interesting to study the capsule molds. They are made in two halves and the tubing of one side is the exact counterpart of the other. The top part is made to slide up and down on the lower half. The lower part is made with raised edges and on the upper part there is a groove in which the raised edges fit. When the pressure from the press is applied the first pressure comes on the collar of the die. This clamps the two sheets of gelatin together and keeps the liquid from escaping and, as there is no other place for the liquid to go, it is forced into the space of the tubing. Thus it bulges the gelatin into the form of half a capsule on each of the dies. As more pressure is put on and the gelatin sheets on the two plates of the press are brought together, the halves of the capsules are united, stuck together, sealed, and finally cut clear from the sheets. The capsules are then brushed off the mold into a tray and the operations repeated. Alcohol, or benzine, is used to wash the finished capsules, after which they are ready for boxing. In the case of hard pearls they are first dried and then varnished with a solution of gum sandarac dissolved in alcohol and ether.

Pastilles to Keep Off Mosquitoes.—Four parts by weight of eucalyptus oil, 1 of anise oil, 35 of fluid paraffine, 60 of solid paraffine. Melt the ingredients together and mold in pastilles.—Dietrich's Manual.

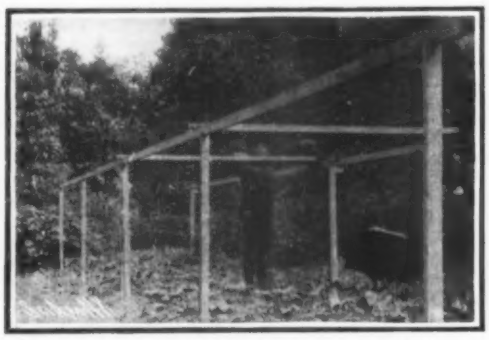
A NEW IRRIGATION SYSTEM.*

By M. ALGER.

THE Norwegian soil is thin and meager, and therefore needs frequent rain in order to produce a fair yield. As a rule the necessary moisture has been plentiful, but during the last three to four years the drought has been a serious drawback to the Norwegian farmers. Thus in the season 1904 the crop deficit, owing to the lack of rain, was estimated at 30 million kroner, or about $8,000,000. Such sad results have given life to the idea of artificial irrigation. A Norwegian physician, Dr. August Koren, Jr., of Christiania, is the inventor of a new irrigation system, especially adapted for gardens and for smaller farms. It has received much favorable comment from interested people as well as from the local press.

The inventor describes his system thus:

The tract of land to be irrigated is first divided into long strips, about 8 meters (26.24 feet) in width. Running along the middle of each strip is placed an open wooden conduit about ½ meter (1.6 feet) above the ground, through which the water is led. The water is distributed at both sides from the conduits by the aid of large zinc sprinklers, which run on small wheels along the edge of the conduits, but somewhat closer to the ground. The sprinklers are 4 meters (13.12 feet) in length, and 0.75 meter (2.46 feet) in width and will, while stationary, water one garden bed at a time, whereupon they may be moved by a man or boy from bed to bed.



THE IRRIGATION PLANT AT WORK.

While the sprinkler remains stationary, distributing water, the gardener may attend to other work in the garden. By this method the work is simplified and made easy, time is economized and sprinkling is effectively accomplished.

The water is carried to the sprinklers from the conduits by the aid of movable conductors of zinc, to which are fastened a rubber hose about 2 meters (6.56 feet) in length. The conductors with the hose are placed in the conduits. When the water is set free in the conduits and the lower part of the hose is placed over its edge in a suitable position, the water runs through the hole, over the edge of the conduits into the sprinkler and is distributed by the latter as desired.

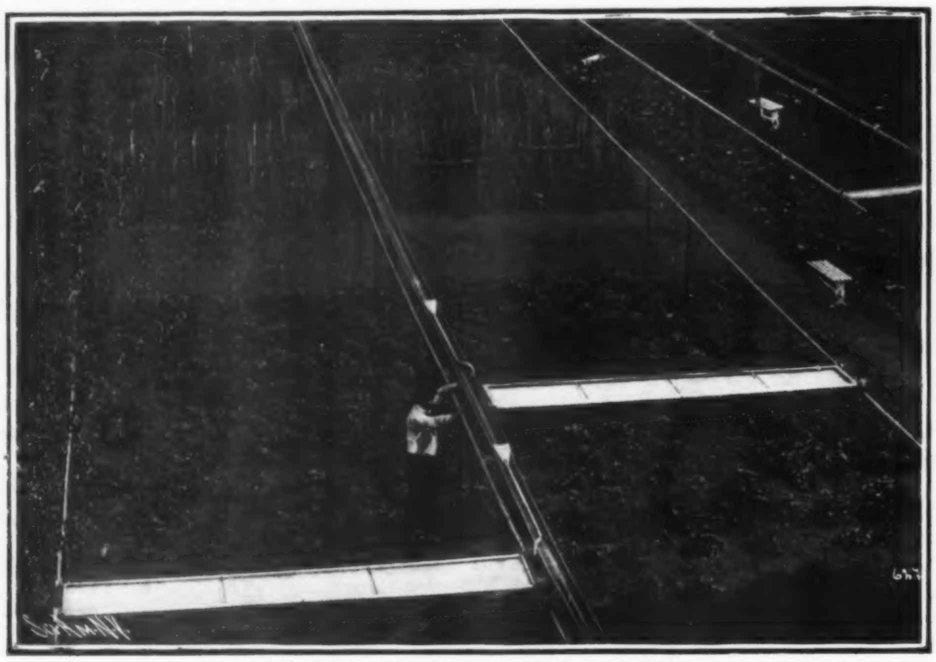
The sprinklers diverge from the usual construction, inasmuch as all their holes or openings are fully provided with small loose-fitting zinc stoppers, which always remain in their places. The stoppers allow the water to escape from their points gently, drop by drop, like rain. This is considered a great advantage, especially when new, tender plants and germinating seeds are to be watered. This new method for causing water to descend gently, which is Dr. Koren's own invention, is believed to be valuable both for technical and industrial purposes, without regard to its importance for use in irrigation. The water also tempers while dripping from the sprinkler.

The conduits as above described are stationary. In gardens their presence will not hinder or be in the way of the attendants or laborers, but in larger tracts they would be an obstacle both during the cultivation and harvesting period. In order to avoid this, Dr. Koren has also constructed a water cart, for use on larger tracts, which is operated on the same principle, with movable sprinklers.

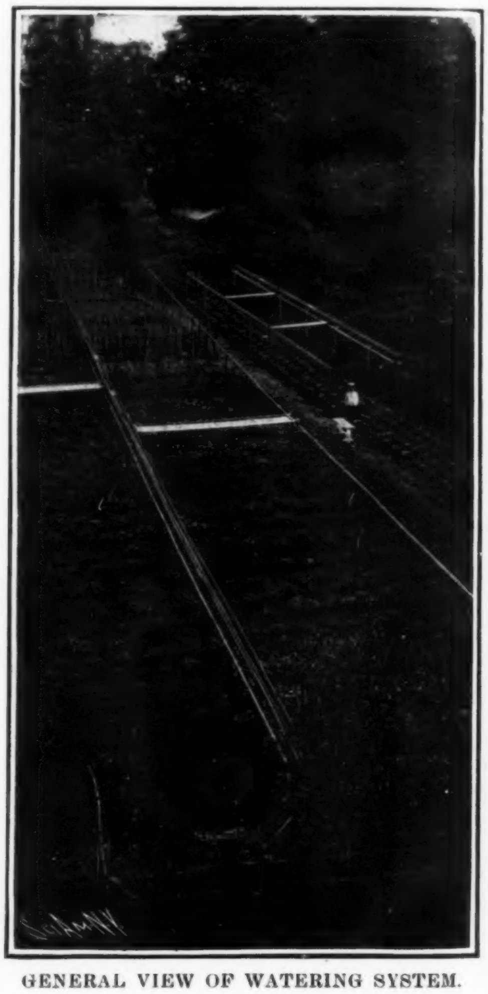
The cart is provided with a motor, driven by water power. The water is forced through a rubber hose, which has been so designed by its ingenious inventor that it will unwind from the spindle when the cart is set in forward motion and again wind itself onto the spindle when the cart is set in backward motion. The cart has consequently to pass once to and fro over each piece of ground, whereafter it passes to the next. The water, supplied from a well or brook, having the required pressure, passes from the hose to a turbine to the left on the cart; the turbine sets the small driving wheels in motion at the direction of the driver. When the water has passed the turbine it is led up into the sprinklers, from which it is evenly distributed over the ground. By turning a water-cock the driver may also pass the water directly from the hose into the sprinklers, without letting it pass the turbine. The cart is manageable in all directions. Its speed can easily be increased or decreased at the will of the driver. The cart is, as before stated, provided with a motor, and horses are consequently not needed; its weight is about 500 kilogrammes (half a ton). With a 25-millimeter (1 inch) hose, inside diameter, and a turbine of 40 centimeters (16 inches) in diameter, and 40 meters (131.2 feet) hydrostatic pressure, the cart should, according to calculations, give about 3.5 horsepower.

The inventor has also constructed a telescopic spraying apparatus which can be used for disinfection and watering of fruit trees in parks, etc. Depending on the size of the apparatus, the point of the sprayer with distributors of different constructions, may be sent from 3 to 8 meters (11.84 to 26.24 feet), according to its size, upward. By this method larger surfaces can be reached than by the common watering turbines, which as a rule are stationary on the ground. The apparatus is so constructed that it can be easily moved, if desired.

Especially interesting is the drop-formation of water at the points of the stoppers, as by this invention irrigation is made possible with a very low water pressure on the sprinkler, a pressure so low, that if there were merely open holes in the sprinkler the water would not run through unless the amount of water be increased.



HOW THE STRAINERS ARE ARRANGED.



GENERAL VIEW OF WATERING SYSTEM.

The telescopic spraying apparatus is also unique in the respect that the water is not released, or in other words, the act of sprinkling does not start until the full extension has taken place.

The territory covered becomes very evenly saturated, giving a trifle more water in the periphery.

* From American Homes and Gardens. Published by Munn & Co.

THE SPECTRUM OF MERCURY.

THE spectrum of mercury is the subject of a paper read by C. de Watteville before the Académie des Sciences. While most of the metals give a spectrum containing a greater or less number of rays when in the flame of a mixture of coal gas and air or in the oxyhydrogen blowpipe, mercury seems to be one of the few metals which do not possess this property. Hartley and Ramage, in the course of their researches, were not able to photograph either lines or bands of mercury when heating the oxide in the oxyhydrogen flame, and M. Gouy arrived at the same negative result with his atomizing apparatus. The failure of these methods may be attributed to the difficulty of decomposing the mercury salts which were used. Watteville lately tried organic compounds, such as the acetate and cyanide of mercury. These bodies were dissolved in distilled water and atomized in illuminating gas in M. Gouy's apparatus. He thus succeeded in obtaining, by the use of a quartz spectrograph, a mercury spectrum which is composed of the single ray 2536.72 measured by Kayser and Runge in the arc spectrum of mercury, where it is very strong and also reversed. This ray is also very intense in the flame, since an exposure of one hour is enough to make it appear well on the photographic plate. He tried as long an exposure as 10 hours in the hope of bringing out some of the other lines, but did not succeed in this. He repeated the experiment with mercuric nitrate solution and found an identical result, and the ray 2536.72 was fixed to the exclusion of all others. Neither with the eye nor by photography could he find any trace of the lines 547 and 435 (using acetate, cyanide, and nitrate), which Mitscherlich stated to have seen in introducing cyanide of mercury into the flame. This fact seems of interest from two standpoints: First, the spectra of the six following metals of Mendeljeff's second group, magnesium, calcium, zinc, strontium, cadmium, barium, are characterized by the presence in each of them of a ray which is much brighter than the others. The aspect of these rays is so striking that Watteville was led to compare them with each other, not being aware of the work of Mr. Ramage, who establishes the relations between the wave-lengths of these rays and the atomic weights of the metals. If we continue the straight line which nearly joins the three points obtained in taking as co-ordinates the wave-lengths (2852, 3075, 3261) and the atomic weights (24.36, 65.4, 112.4) of the metals magnesium, zinc, and cadmium, we find that the analogous line for mercury should be the line 3650.31, which is very strong in the arc. But, as we have seen, this ray is absent in the spectra which are obtained in the same way as for the other metals. Besides, in spite of the high molecular weight of mercury, the only line which is found has a wave-length of 2536, which is much shorter than the line 2852 of magnesium, the latter being the most refrangible of those seen in the flame of the above six metals. In the second place we may remark that the solar spectrum does not contain any lines of mercury. If this metal is found in the sun under the conditions where it can only emit the ray 2536.72, this latter will be situated in the point of the spectrum which is absorbed by the earth's atmosphere. It follows from this that we must not conclude the absence of mercury in the sun even though we do not find any trace of it in the spectrum.

PHONOGRAPHS AS EVIDENCE.

THE first instance, doubtless, of the use of a phonograph in a court of this country as evidence occurred, according to the newspapers, in a recent trial in the United States Court at Boston. Evidence of a similar character, it is said by the press report, has been allowed in England. No regular report of these cases has yet come to hand. In the Boston case it is said that the phonograph was put in evidence to show the court the noise of the elevated cars, for which the plaintiff claimed damage to his business block. The evidence was objected to, of course, and, in support of its admission, the plaintiff's counsel contended that a phonograph is one of the most accurate scientific recorders, and that it is admissible in evidence on the same ground that photographs are admissible. That photographs constitute proper evidence, though stoutly denied at the outset, has been established in a great

number of cases, and the limitations of their use for that purpose are shown in an extended note in 35 L. R. A., 802, to the case of Dederichs v. Salt Lake City R. R. X-ray photographs have also been accepted in evidence, as shown by that note, and also by the case of Geneva v. Burnett, 65 Neb., 464; 58 L. R. A., 287; 101 Am. St. Rep., 628; 91 N. W., 275. Another new kind of evidence created by modern scientific developments is that furnished by telephones, and the right to put telephone conversations in evidence, though not universally conceded, has been upheld in a number of decisions, as shown in Oskamp v. Gadsden, 35 Neb., 7; 17 L. R. A., 440; 37 Am. St. Rep., 428; 52 N. W., 718, and the annotation to that case. Whatever restrictions or conditions the courts may impose on the use of phonographs in evidence, it is not to be doubted that they will ultimately come to be regarded by the courts as evidence no less reliable than photographs, X-ray pictures, and telephones.—Case and Comment, January, 1906.

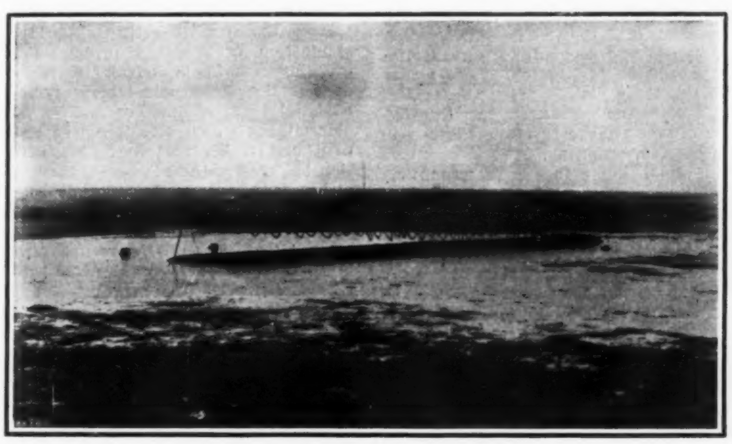
PLOVER NETTING IN THE FENS.

OUR first illustration represents some of the machinery for catching plovers, although at first sight it might pass for a picture of what they call a "promising city" in the Far West, with its mill-pump and solid-looking shanty in the foreground, and the illimitable prairie stretching to the horizon. But if your eye follows the trench which goes from the pump toward the horizon for about 60 yards, you will see that it ends in a small sheet of water. The next illustration gives a nearer view of this miniature lake, which has a long, narrow island in the center and a few tiny islets, scarcely bigger than molehills, sticking up out of the water. This is the plover decoy, and the object of the water-windmill, in the first picture, is simply to keep the lake, some 20 yards in diameter, full of water. It is upon the use of the tiny islets that cause for action, under the Protection Acts, may arise; for one need hardly remark that the snarer, crouching in his hut 50 yards away, does not periodically expose himself in the open, tramping across the 50 yards of open space between himself and the decoy, and paddling in the water to ascertain whether the tethered plovers on their separate islets are becoming fatigued.

These illustrations exhibit well the terrible monotony of flatness in Fens, and it is on account of this feature of the landscape that the plover-snarers are able to make such large and frequent hauls as to recoup themselves for the outlay of their elaborate preparations. Wandering flocks of birds are always distrustful of strange landscapes. When the weary migrants reach our shores in autumn you may watch them drifting irresolutely across the sky, calling as they go. Presently a responsive call of their own kind arises from the earth below; and, at once, with a rushing sound of half-closed pinions the crowd of travelers swoop earthward toward the spot whence the welcome sound proceeded. Sometimes it was only the clever mimicry of a hidden shore-shooter, and two barrels are emptied into the thick of the close-packed birds before they discover the deception and wheel aloft to find a less treacherous resting place. And ground birds, like the plovers, are peculiarly liable to fall into such ambush. Perching migrants, such as fieldfares or redwings, can crowd with safety into the topmost branches of lofty trees and thence survey the landscape carefully before they descend to the ground. But for the plover there is no halfway house between sky and earth. So you may see him, circling and wheeling by thousands together, ere he dares to alight; now swooping down with a murmurous rhythm of wings like the folding of many newspapers, now shooting aloft with the momentum of his descent, and skimming obliquely over many acres, for the land bristles with perils, and instinct teaches the plover to beware of alighting where any chance of danger lurks. Only one circumstance will give him perfect confidence, and that is the presence of other plovers. So, when the wheeling myriads discover a welcome sheet of water, studded with islets, upon which members of their own kind are standing, they boldly drop toward them; and, in doing so, they discover that a long, low island in the midst of the water is the only place where they have room to settle near their friends. But it is the victims' landing place. It has been richly baited with worms, and, for a brief moment, the thronging wayfarers think that they have chanced upon a hospitable land indeed; but from end to end stretches the fatal net, which falls just at the right moment to envelope the fluttering multitude.

For it is at this point that the utility of the substantial-looking shanty of our first illustration comes in. A nearer view shows it to be the snarer's hut, and if you look carefully at this last picture you will just see the line, which he is holding, stretching taut and straight to the right, in which direction, at some 50 yards distance, is situated the decoy represented in the previous pictures. The hut, built solidly of turfs and trenched round to save the snarer from being washed out in case of rain, is fringed with dead stalks of rank Fen herbage, and, to the plovers' "bird's-eye" view of the landscape suggests only a solid mound, neglected and overgrown. But from it human eyes are watching their movements, and a ready hand grips the cord which controls the distant net. Thus the very caution of the bird delivers it helpless into the hand of man; for it is only because the plovers are so very careful not to alight except where it seems absolutely safe that man is able to decoy them within his reach.—Country Life (London).

MACHINE FOR CATCHING PLOVER.



THE VICTIMS' LANDING PLACE.

SOME RECENT RESULTS OF STUDIES ON HEREDITY.

By J. PERCY MOORE.

THAT the progeny of animals and plants are fashioned each after its kind, and that in general the young resemble their parents more closely than any other individuals are phenomena so constantly before us that most of us simply accept them as fundamental facts of nature. Heredity is a property or function of the living substance, protoplasm, as the crystallographic habit is a property of minerals. While this conclusion is doubtless true in the very broad sense that the inherent activities of an animal or plant depend in the last analysis on its chemical composition and physical organization, there are certain evident differences between organic heredity and the form repetition of minerals.

In the first place no two individuals of a plant or animal species are exactly alike. They vary in a more or less indeterminate way, and some of them depart widely from their parental type. These variations cannot usually be traced to any such simple influences as the mechanical pressures and interferences which produce alterations in the form of crystals. Many of them arise as the result of influences inherent in the organism which exhibits them; and in such a manner that we are forced to believe that they have been transmitted from a previous generation in which they arose.

A second important difference is that in sexual reproduction, through the medium of which the hereditary forces act, each parent contributes but a minute part of its body, in animals a single ovum or a single spermatozoan, to the formation of the progeny. The latter arises from a single fertilized egg cell; and by processes of growth and change through courses more or less indirect and devious gradually assumes the adult form of its parents. The nature of the successive forms which an organism takes on during its development is more or less influenced by the ancestral history, remote and recent, of its lineage. Nothing at all resembling this takes place in the formation of mineral crystals. Crystallization much more nearly resembles the processes of regeneration of lost parts or of vegetative growth in animals and plants.

It is this compression of the entire heritage of the race within the compass of a minute germ that has always excited the wonder of thoughtful minds, and has led to the drafting of numerous hypotheses to account for the mechanism by which qualities are transmitted. By what mysterious machinery are the potentialities of the hen and her lord concentrated within the fertile germinal spot of the egg and again loosed and unfolded in the developing chick? All of the painstaking labor which has been directed toward the solution of this question has resulted in establishing the fact that the bearers of certain classes of characters which have become so fundamentally fixed upon the organism that the germinal substance is thereby modified are contained in a certain substance localized in the nuclei of the germ cells. We are as far as ever from fathoming the real mystery of heredity.

There is, however, another side to the question and another and more promising line of investigation opens, namely, the behavior of specific characters in heredity and the course of their transmission from generation to generation. The human importance of this subject is so vast that efforts to find means of controlling or foretelling the course of heredity have been general and persistent. Sociologists foresee in success not only the elimination of disease and crime from human society, but the strengthening of the better physical, mental, and moral attributes, the amalgamation of the best qualities of various races, and in general the improvement of the human species. Less visionary, perhaps, is the outlook of the breeder, who has already "created" and controlled, to meet the ever-expanding needs of civilized man, many new and improved varieties of domesticated animals and plants, and whose claim to have been the most potent single influence in uplifting man from savagery is undoubtedly well founded.

The experience of breeders and other students of heredity has long since made familiar the fact that all characters do not exhibit a similar transmission behavior. Some possess a remarkable force and persistence, others are quickly suppressed, or appear only at long and irregular intervals, or in a minority of the offspring. Some are paired and alternative to others, with which they seldom or never mix. They appear to be antagonistic or mutually exclusive. Such are light and dark eyes in the human species. Of the children of parents who differ in this respect some will have eyes with the iris pigmented blue, some with it brown, but very seldom of an intermediate color. On the other hand certain characters blend in heredity, and with respect to such the offspring are on the average a mean between the two parents and their accumulated ancestry. Children born to white and negro unions have the skin of an intermediate hue, and in crosses of whatever degree the depth of pigmentation is in general an expression of the relative amounts of white and negro blood present in the mixture. Stature as a rule behaves similarly. Again, parental qualities, while

THE SNARER'S HUT.

not actually blending, may mix in a mosaic or patchwork form, as occurs, for example, in the piebald distribution of pigments in the skin of circus ponies, certain fanciers' breeds of rats and mice, etc. Some characters are correlated with or bound to others in heredity, as are certain physical characters with the sex of the parent in reciprocal crosses between the horse and ass to produce the mule or hinny. Furthermore, a character may exhibit cumulative strength; or it may decline and disappear. A totally new character may appear suddenly and possess great transmission force from the start; or a long dormant ancestral character may as suddenly become apparent and then persist with remarkable tenacity, or quickly disappear from succeeding generations. The behavior of these various kinds is very puzzling, and until recently there has been practically no known method of analyzing them with certainty, and no scientific explanation of any one of them.

A great step forward in the understanding of the laws governing the course of heredity was undoubtedly made when Francis Galton, a cousin of Charles Darwin, showed that it is possible to express mathematically the average ancestral influence in heredity. By the application of purely statistical methods to the study of such blending qualities as human stature and the coat colors of certain breeds of hounds he secured data for the formulation of what is now known as Galton's law of ancestral influence in heredity. According to this law of the characters inherited by the progeny the two parents contribute in general one-half, the four grandparents one-quarter, the eight great-grandparents one-eighth, and so on. In general the influence in heredity of any ancestral generation is inversely proportional to the total number of individuals comprised in that generation. Later studies by Pierson and others have amplified this law and given to it greater precision for blended characters. Notwithstanding that it expresses an important truth, Galton's law has been and must be of very limited practical value to the breeder. It is retrospective in character, and, while it serves as an expression of the average ancestral contribution to the entire heritage of a descendant, it gives no clue to the part which any particular individual is likely to play in the determination of the characters of his prospective descendants. It merely teaches us more precisely what was well known before, that a descendant is the more likely to be tall as the average height of his ancestors exceeds the mean for the race, and the like.

It is in the field of alternative characters, however, that the application of careful experimental, statistical, and analytical methods has gained its great triumphs over the method of unguided observation. Working alone and unheeded in the garden of the Augustinian Monastery of Brünn, in Austria, the Abbot Mendel laid the foundations for this newer work forty years ago. But so busily occupied were scientific men with the Darwinian controversy then raging that Mendel's two modest papers were overlooked. Not until 1901, when others had reached the same conclusions, were they rediscovered and their contents made known to the world. No fewer than four different botanists engaged in plant-breeding in as many countries—De Vries in Holland, Correns in Germany, Tschermak in Austria, and Spillman in America—rediscovered the same principles independently. Both botanists and zoologists have been quick to see the importance of Mendel's Law, as the formulation of the principles discovered by him is now appropriately designated. It is not too much to say that the progress made toward a really scientific knowledge of the course of heredity under the stimulus of Mendel's work in the last five or six years is more important than that of the past centuries.

Mendel's experiments with garden peas illustrate admirably the new method and its results. His method differs from that of previous breeders in the care with which all the progeny from each cross were kept separate for a number of successive generations. He selected for observation a number of contrasted characters which are alternative in nature and never appear together in the same individual. Among these, were whether the cotyledons were green or yellow, the seeds round or angular, the pods wrinkled or smooth, the stems tall or dwarfed, etc. Taking varieties differing in respect to one or more of these characters he cross-pollenated the flowers and saved and planted all of the hybrid seed produced and those of the progeny of the latter for several generations. The characters exhibited by all of the offspring were carefully observed and the results tabulated. The result of his painstaking work was the discovery of two entirely new and unexpected principles which may be best explained by a simple illustration.

Let us follow the results in crossing peas differing only in the yellow color of the cotyledons of one variety and the green color of the other. All of the cross-pollenated flowers of the original cross produce yellow seeds only; none are green and none intermediate in color. The green color is totally suppressed as a visible character. This is Mendel's principle of dominance; the patent character he terms the dominant, the suppressed one the recessive. All of this first hybrid generation resemble the yellow-seeded or dominant parent. If all of these seeds be now grown and the plants in turn set seed, the latter will be partly yellow and partly green and always in the proportion of approximately three of the former to one of the latter.

This illustrates the principle of the segregation of characters. The alternative characters separate in the germ cells in such a way that each germ cell carries either the dominant or recessive character of a pair but, under ordinary circumstances, never both. Thus in the case of plants there are ovules which bear the dominant and those which bear the recessive character, as well as dominant pollen and recessive pollen. Now as each of these kinds is ordinarily produced in equal numbers and every seed results from the union of one ovule and one pollen grain it follows that in general each kind of ovule will be fertilized an equal number of times by each kind of pollen grain. This is most clearly expressed by the following symbolic formula, in which D represents the dominant and R the recessive character, the latter being included in parentheses when latent in the presence of its dominant. The hybrids of the first cross-bred generation will produce

Ovules D *and* R *fertilized by*
Pollen D *and* R *resulting in*
Progeny $DD, D(R), (R)D$ *and* RR.

That is, in the case of the cross between yellow and green peas, there result in the second hybrid generation progeny, one-fourth of which are pure recessives having green seeds, one-fourth pure dominants with yellow seeds, and one-half unstable hybrids with yellow seeds, but which contain the recessive green character in a latent form. The green-seeded peas may be separated, and if close-bred will never produce any but green-seeded progeny. The yellow-seeded peas are all exactly alike and it is not possible at this time to separate the pure dominants from the hybrids. This is, however, easily done by self-pollenating each of the plants produced from these yellow seeds. The dominant class will produce yellow seeds alone while the hybrids will again produce, as before, yellow and green seeds in the proportion of 3 to 1.

Some actual figures based on extensive experiments will give concreteness to these statements. Mendel, dealing with the characters employed in the above illustration, records that 258 hybrid plants grown from yellow seeds produced in the second generation 8,023 seeds, of which 6,022 were yellow and 2,001 green, the ratio being 3.01 to 1. In the next generation, of 519 plants grown from the yellow seeds, 166 yielded yellow seeds exclusively and 353 yielded yellow and green seeds, in the proportion of 3 to 1. The yellow seeds therefore produce hybrid and constant or pure dominant forms in the proportion of 2.13 to 1. The plants grown from the green seeds yielded green seeds only. Such experiments explain the well-known fact that hybrids bred *inter se* always tend to revert to the parent types from which they have sprung.

While the case of simple dominance in crosses differing by one alternative character fully illustrates the nature of the basic principles of Mendelian breeding, it can have no importance in the actual production of new varieties. The problem of the practical breeder is far more complex. Perhaps the simplest case with which he has to deal is the combination in one stock of two desirable qualities which have appeared in separate individuals or strains. Exactly the same principles apply to such cases, by however many alternative characters the varieties or species may differ, and for however many generations they may be cross-bred. They have been fully tested and verified in crosses involving 3 and 4 pairs of characters.

It is clear, however, that the number of possible combinations of characters and the number of visibly distinct classes of offspring must increase very rapidly with the number of differential characters. Thus in the second hybrid generation of crosses differing in respect to two pairs of alternative characters there will be sixteen possible combinations, of which seven are reciprocal and of identical nature, leaving nine distinct classes which behave differently in heredity. Four of these are pure, and represent the four possible combinations of the differential characters concerned. The other five are unstable hybrids of various compositions, but all containing in latent form one or both recessive characters, which on further breeding will appear in a definite percentage of the progeny. The history of all of these has been repeatedly ascertained and the formulæ representing each worked out for both plants and animals.

In order to illustrate how the principles of dominance and segregation may be employed in practical breeding we may suppose a simple case, the data for which have been fully worked out by Dr. Castle. Let us suppose that a breeder of guinea pigs is desirous of producing a pure stock of rough-coated or "rosetted" albinos, and has available for breeding purposes only animals which exhibit these characters in the combinations of rough with pigmented coat and albino with smooth coat. The desired result can be attained much more quickly and certainly by the Mendelian than by the usual method of crossing and selection, which may fail to separate the pure stock.

Dr. Castle's experiments have shown that rough coat is alternative with and dominant over smooth coat, and that white coat is alternative with and recessive to pigmented coat. Crossing the rough-pigmented animals with the smooth albinos there are produced hybrids, all of which exhibit only the dominant coat characters of roughness and pigmentation. When these are bred *inter se* their progeny split into nine distinct (though not all immediately visibly so) categories, in some of which the latent recessive characters of albinism and smooth coat have appeared. Out of every sixteen of these progeny three on the average will exhibit the combination of characters desired. The white coat will also be present in latent form in some of the other progeny.

An inexperienced breeder would perhaps conclude that his object had been attained, and would proceed to breed together indiscriminately the most vigorous individuals exhibiting the rough white coat, with the result that many of the progeny would have smooth white coats. As such individuals would be discarded, the pure stock desired would probably be secured sooner or later by the more or less lucky accident of crossing animals which are pure in the sense that they do not contain the recessive character of smoothness. To the Mendelian breeder several courses of procedure would be open. One of the simplest would be to test each of his rough-coated albinos for purity by crossing each with a smooth-coated albino, which contains the recessive characters only. The result would be that about one-third of the rough, white animals would produce to this cross only progeny similar to themselves, while the other two-thirds would produce mixed progeny in the usual proportions of three rough albinos to one smooth albino. The individuals which yield offspring of one kind only are the pure stock sought and will remain pure as long as they continue to be inbred. The test is as decisive as the chemist's tests for metals in a solution of unknown composition.

The theoretical explanation of Mendel's law receives strong support from the fact that there exists the germ cells, a mechanism by which the segregation of characters may be brought about in exactly the proportions described. A long series of careful researches have proved that certain qualities are transmitted through the agency of the so-called chromatin or deeply straining substance of the nucleus. This material is arranged in the form of separate particles or chromosomes and is derived in equal parts from the male and female parent. When the germ cells are becoming ripe these chromosomes first unite in pairs and are then divided equally between two cells in the most precise manner. These remarkable processes afford the means for rearranging and then segregating in distinct germ cells the bearers of alternative characters in exactly the way that Mendel's law requires. While segregation thus finds its explanation, dominance remains totally unaccounted for. We have no clue whatever as to why some characters should appear in perfect development whenever their dominant partner is absent.

It is too soon to estimate the importance of the application of Mendel's principles in the practical breeding of animals and plants. Very much has been done in the garden and laboratory in establishing the essential truth of the law and its corollaries and in determining which of alternative characters is dominant and which recessive. Much valuable information has been gathered; but apparently few professional breeders have applied the new method to their art and until they do its value as a working method must remain undetermined. The opinion that has been expressed that, because the actual varieties handled by breeders differ in many characters, the Mendelian procedure will prove too complicated and cumbersome is probably not well founded. On the contrary it would seem that its application would tend to simplify greatly and to give precision to the work of the breeder. The really essential qualities by which desirable breeds differ are not many, and the minor characters are generally unimportant and variable. This is clearly shown by the adoption of sliding scales of values for the guidance of judges in awarding prizes at breeders' shows.

By the employment of Mendelian methods the breeder should be enabled quickly to separate these hybrid categories which alone embody the desired combinations of qualities. Complex hybrids can be analyzed and split into simpler combinations which can then be dealt with more effectually for the elimination of objectionable and the retention of desirable features. Latent characters can be more quickly detected and more certainly controlled than by the old methods. The true composition of a stock having been once determined the constituents may be recombined much more quickly and definitely than by the methods now in use, and in the simpler cases at least almost at will, as has actually been done already with peas, beans, wheat, cotton, various flowering plants, mice, rats, rabbits, guinea pigs, chickens, and perhaps a score of other plants and animals. The advantage of Mendelian breeding over the old practice is that of combining elements of known composition and behavior over that of mixing those of unknown composition and uncertain behavior.

While it is not probable that the employment of Mendel's method will result in any greater triumphs in the improvement of old varieties or the production of new ones than have present methods in the hands of such a genius in plant breeding as Luther Burbank, it seems probable that it will at least enable the breeder to fix his new types much more quickly and completely and save him much time and labor in the avoidance of futile attempts to hybridize impossible combinations. Although discovered and chiefly investigated by botanists, it seems probable that these principles will prove of even greater value to breeders of animals than of plants, because of the greater importance of maintaining purity in the former. In the case of perennial plants it is generally necessary to produce only a single vigorous individual of a desired variety. And no matter how unstable the germinal composition of a hybrid may be, it may be propagated indefinitely from cuttings, buds, and grafts, which are simply detached portions of the original plant. The grower need have no concern about germinal purity. Most of our fruit trees, roses, etc., are notoriously unstable and variable when grown from seed, which is evidence of their complex hybrid character. The same holds true for an-

nuals propagated from tubers, bulbs, and cuttings. For annual plants regularly grown from seed, and for all domestic animals the importance of germinal purity in order to maintain the standard of the race is obvious from the facts previously outlined.

Perhaps it will not be many years before the breeder, like the engineer, will be provided with his rule book, in which will be printed Mendelian tables of paired characters fully tested for dominance, recessiveness, and purity in various animals and under various conditions. Therein will be found Mendelian formulæ fully worked out for all possible combinations of the different types of homozygote and heterozygote in different animals, established Mendelian pedigrees and other equally valuable tables. The breeder will then be able, perhaps, to produce to order within a contract time, a new variety having certain specified characters with something approaching the certainty with which an engineer plans and builds a bridge, or a chemist produces a new synthetic compound. This is a vision inspired by the picture held before us by the most enthusiastic workers in Mendelian fields.

THE WRIGHT BROTHERS' FLYING MACHINE AND WHAT IT HAS ACCOMPLISHED.

In a communication made last month to the newly-formed Aero Club of America, the Messrs. Orville and Wilbur Wright, of Dayton, Ohio, detail the development of their man-carrying, motor-driven aeroplane, and tell, in the following words, what they have accomplished with it:

"Though America, through the labors of Prof. Langley, Mr. Chanute, and others, had acquired not less than ten years ago the recognized leadership in that branch of aeronautics which pertains to birdlike flight, it has not heretofore been possible for American workers to present a summary of each year's experiments to a society of their own country devoted exclusively to the promotion of aeronautic studies and sports. It is with great pleasure, therefore, that we now find ourselves able to make a report to such a society.

"Previous to the year 1905 we had experimented at Kitty Hawk, N. C., with man-carrying gliding machines in the years 1900, 1901, 1902, and 1903; and with a man-carrying motor flyer, which, on the 17th day of December, 1903, sustained itself in the air for 59 seconds, during which time it advanced against a 20-mile wind a distance of 852 feet. Flights to the number of more than a hundred had also been made at Dayton, Ohio, in 1904, with a second motor flyer. Of these flights, a complete circle made for the first time on the 20th of September, and two flights of three miles each made on the 9th of November and the 1st of December, respectively, were the more notable performances.

"The object of the 1905 experiments was to determine the cause and discover remedies for several obscure and somewhat rare difficulties which had been encountered in some of the 1904 flights, and which it was necessary to overcome before it would be safe to employ flyers for practical purposes. The experiments were made in a swampy meadow about eight miles east of Dayton, Ohio, and continued from June until the early days of October, when the impossibility of longer maintaining privacy necessitated their discontinuance.

"Owing to frequent experimental changes in the machine and the resulting differences in its management, the earlier flights were short; but toward the middle of September means of correcting the obscure troubles were found and the flyer was at last brought under satisfactory control. From this time forward almost every flight established a new record. In the following schedule the duration, distance, and cause of stopping are given for some of the later flights:

Date.	Distance. Miles.	Time. Min.	Sec.	Cause of Stopping.
Sept. 26....	11⅛	18	09	Exhaustion of fuel.
Sept. 29....	12	19	55	Exhaustion of fuel.
Sept. 30....	....	17	15	Hot bearing.
Oct. 3....	15¼	25	05	Hot bearing.
Oct. 4....	20¾	33	17	Hot bearing.
Oct. 5....	24 1-5	38	03	Exhaustion of fuel.

"It will be seen that an average speed of a little more than 38 miles an hour was maintained in the last flight. All of the flights were made over a circular course of about three-fourths of a mile to the lap, which reduced the speed somewhat. The machine increased its velocity on the straight parts of the course and slowed down on the curves. It is believed that in straight flight the normal speed is more than 40 miles an hour. In the earlier of the flights named above less than six pounds of gasoline was carried. In the later ones a tank was fitted large enough to hold fuel for an hour, but by oversight it was not completely filled before the flight of October 5.

"In the past three years a total of 160 flights has been made with our motor-driven flyers, and a total distance of almost exactly 160 miles covered, an average of a mile to each flight, but until the machine had received its final improvements the flights were mostly short, as is evidenced by the fact that the flight of October 5 was longer than the 105 flights of the year 1904 together.

"The lengths of the flights were measured by a Richard anemometer which was attached to the machine. The records were found to agree closely with the distances measured over the ground when the flights were made in calm air over a straight course; but when the flights were made in circles a close comparison was impossible, because it was not practicable accurately to trace the course over the ground. In the flight of October 5 a total of 29.7 circuits of the field was made. The times were taken with stop watches. In operating the machine it has been our custom for many years to alternate in making flights, and such care has been observed that neither of us has suffered any serious injury, though in the earlier flights our ignorance and the inadequacy of the means of control made the work exceedingly dangerous.

"The 1905 flyer had a total weight of about 925 pounds, including the operator, and was of such substantial construction as to be able to make landings at high speed without being strained or broken. From the beginning the prime object was to devise a machine of practical utility, rather than a useless and extravagant toy. For this reason extreme lightness of construction has always been resolutely rejected. On the other hand, every effort has been made to increase the scientific efficiency of the wings and screws in order that even heavily built machines may be carried with a moderate expenditure of power. The favorable results which have been obtained have been due to improvements in flying quality, resulting from more scientific design, and to improved methods of balancing and steering. The motor and machinery possess no extraordinary qualities. The best dividends on the labor invested have invariably come from seeking more knowledge rather than more power."

The facts contained in a letter of Orville Wright to the Aeronautical Society of Great Britain, written under date of November 17, 1905, will also be of interest:

"All these flights were made at about 38 miles an hour, the longest occupying over half an hour. Landings were caused by the exhaustion of fuel or by heating of the bearings in parts of the motor to which oil cups had not then been fitted. Before the flight of October 5, oil cups had been fitted to all the bearings, and the small gasoline can had been replaced with one which carried enough fuel for an hour's flight. Unfortunately, we neglected to refill the reservoir just before starting, and in consequence the flight was limited to 38 minutes. The machine passed through all these flights without the slightest damage. In each of these flights we returned frequently to the starting point, passing high over the heads of the spectators."

It will be noted that although a complete description is here given by the Wright brothers of what they accomplished, nothing whatever was said of the means by which they have succeeded in flying. We understand, however, from other sources, that their motor-driven machine is very similar to their original glider, with which they experimented during the years 1900-1903. The motor-driven aeroplane consists of two long, rectangular, superposed planes some 40 feet in length by 6 feet wide, and having a space of 6 feet separating them. These planes are connected by vertical posts, and are stayed and reinforced by diagonal piano wires, thus making a very strong and rigid connection. A four-cylinder, four-cycle, vertical, air-cooled motor of about 24 horse-power is placed at the rear part and in the center of the lower plane. It drives, by means of chains, two propellers mounted about half way between the upper and lower planes and placed some 10 or 15 feet apart. Behind each propeller is a vertical rudder, the two being connected together so that they will move in unison. The operator lies flat upon the lower aeroplane at its center part, and directly in front of the motor. His head is immediately below two superposed, horizontal, guiding planes, the angle of which he can alter and thus control the inclination and elevation of the aeroplane. The motor is said to weigh some 250 pounds, and a balance weight of 50 pounds is said to be placed in the front of the machine, in order to counterbalance the weight of the motor at the rear. The total weight of the machine and operator is 925 pounds, and the weight per horse-power which it is possible to sustain with it at speeds ranging around 40 miles an hour, has been found to be in the neighborhood of 60 pounds.

The aeroplane rests on runners when it alights upon the ground, and when starting it is placed upon a small carriage which runs on wheels on an ordinary rail some 40 feet in length. This rail is laid horizontally upon supports which raise it about 6 inches from the ground. With the aid of two men to steady and push the machine, its propellers will cause it to rise from the rail after it has traveled about half the length of the same. The machine is so substantially built that it can alight at a considerable speed on soft earth without being damaged. In view of the fact that the motor and all parts of the machine are much heavier than they need necessarily be for strength, it seems probable that in a short time one of these machines little if any larger in size will be able to carry two people as readily as it now carries one. The solving of the problem of stability of this type of aeroplane (which is about the most unstable of all types), even though it has been as thoroughly done as would appear, makes it seem probable that other forms of aeroplanes, which have greater inherent stability but less lifting power, will soon supersede the elongated planes now used by the Wrights.

The Aero Club at its last meeting passed this resolution:

Whereas, The Messrs. Wright brothers, Wilbur and Orville, of Dayton, Ohio, have developed an aeroplane type of flying machine that many times has carried a man safely through the air at high speed, and continuously over long distances, and, therefore, of practical value to mankind; therefore, be it

Resolved, That the Aero Club of America hereby expresses to them its hearty felicitations on their great achievement in devising, constructing and operating a successful man-carrying dynamic flying machine; and be it further

Resolved, That a copy of these resolutions be addressed to Messrs. Wilbur and Orville Wright, at Dayton, Ohio.

Santos Dumont, who is a member of the Aero Club of America, and who is to be one of the club's representatives in the coming international balloon contest in France, is at work on a machine with which he expects to win the Deutsch-Archdeacon $10,000 prize for machines heavier than air. According to the SCIENTIFIC AMERICAN, this machine is to be a helicoptère, or screw flyer, that is to say, an apparatus which will raise, support, and propel itself through the air solely by the powers of horizontal and vertical propellers. The frame and the rigging, like those of the dirigible balloons of the same inventor, are made entirely of bamboo, silk, and piano wire; and only the motor and the mechanism for the transmission of power are formed necessarily of heavier metal parts. This machine will weigh 352 pounds, and it will be furnished with a 24-horse-power air-cooled motor weighing 77.16 pounds, or about 3¼ pounds to the horse-power.

"The helicoptère is formed of a rectangular frame of bamboo," says the SCIENTIFIC AMERICAN, "which carries at its ends the vertical shafts of the upper or lifting propellers. In the middle frame is a third vertical axis, which, prolonged downward, serves as a support for the motor platform. A driving propeller is attached to the bow of the skeleton craft and a rudder to the stern. The total length of the apparatus is 41 feet and the total height 19.68 feet. The motor drives by bevel gear a vertical shaft, carrying at its upper end two small pulleys which transmit the motion, by belts, to two bicycle wheels 3.93 feet in diameter, mounted horizontally on the shafts of the lifting propellers. One of the belts is straight, and the other is crossed, so that the two propellers rotate in opposite directions. A bevel pinion which can be thrown in and out of gear permits the horizontal shaft to be started and stopped at will. Finally, the whole apparatus is stiffened by shrouds of piano wire, so arranged as to resist deformation stresses. A yard, attached at right angles to the lower side of the frame and fastened firmly by stays to the other pieces, assures transverse stability.

"Two details are of sufficient importance to deserve special mention. In the first place, in order to prevent deformation of the lifting propellers and to make possible their extraordinary lightness of construction, M. Santos Dumont drives them, not by the motion of the shaft on which they are mounted, but by means of wires which connect various points of their blades to the bicycle wheels to which the power of the motor is transmitted. In the second place, the rudder presents a peculiarity of being movable about a horizontal axis.

"The motor is of the eight-cylinder type, and M. Santos Dumont, in order to reduce the weight of the machine to a minimum, will employ for the operator's seat an ordinary bicycle saddle attached to the platform of the motor.

"The complete apparatus, manned and equipped, weighs 352¾ pounds, of which 231½ pounds represents the weight of the helicoptère and 121¼ pounds that of the aeronaut and a few indispensable instruments.

"These figures show how far M. Santos Dumont has gone in eliminating everything that appears to him superfluous. With a lifting power of 22 pounds per horse-power, the 18 horse-power which the inventor expects to develop at the propellers should produce an ascensional force of 396 pounds, or 44 pounds more than the total weight of machine and operator."

THE PERFECTING OF THE AEROPLANE FLYING MACHINE.

By LIVINGSTON WRIGHT.

THE originality of the Wright brothers' machine, the particular point at which lies its chief departure from previous usage, is in the invention and application of a practicable system of control over the apparatus when it is once in the air. The working out of a new system of control is the great initial advance made by the Wrights over all their predecessors. This step, when once taken, enabled them by practice to attain complete success.

Theoretically, the balancing and guiding of a flying machine is simple enough, consisting merely in controlling the relation between the center of gravity and the center of pressure. If the two are coincident, the machine driven through the air will remain level. It will tip neither forward nor back, to the right nor to the left. In actual practice, however, the two centers will not remain coincident for a single second. The center of pressure particularly will shift and vary its position constantly and in all directions. The first thing the Wrights did was to remove the smaller aero-curve, or rudder, from the rear and place it in front. The angle at which this secondary aero-curve is presented to the wind can force the center of pressure for the entire contrivance in front of the center of gravity, thus raising the front end and causing the machine to soar, or it can allow the center of pressure to drop behind the center of gravity, thus depressing the front end of the airship and directing it to earth. But the chief advantage of this rudder and front arrangement lies in the increase it affords in stability. The center of pressure in an aero-curve moving for-

ward through the air, tends to move backward. The difficulty has always been to keep the center of pressure far enough forward to prevent the rear end of the aero-curve from being lifted up bodily and the entire apparatus from being tipped over completely. Earlier experimenters had sought to protect themselves from such a disaster by altering the angle of a rudder placed in the rear. The Wrights were the first to recognize the enormous advance in efficiency in this respect to be gained by moving the rudder to the front. To maintain the side-to-side balance of the machine, the Wrights devised another new and improved method. The lateral control of an aero-curve carrying a man through the air depends upon keeping the center of pressure and the center of gravity in the same straight line from the front to the back. If the center of pressure moves to either side, allowing one end or the other of the machine to dip, the aero-curve will turn in the direction of the lowered end. If this dip is too great or too sudden, caused perhaps by some gust of wind blowing against the surface of the aero-curve from an unexpected quarter, the machine might easily lose its balance completely and tumble over sideways. To secure lateral control, to get at will the dip necessary for steering, and to avoid undesired or dangerous dips, the Wrights adopted the method of shifting and twisting the main wings, equivalent to presenting one end of them at a different angle from the other end. The mechanism by which they accomplish this wing torsion appears to be a part of the secret which they are said to have sold for three hundred thousand dollars. It is involved apparently in a rearrangement of the wires trussing together the two superimposed aero-curves, which renders it possible to loosen or tighten on either side by simply loosening or tightening one of them. The advantage in the Wrights' method consists chiefly in reducing the amount of mental and muscular agility required from the operator. So long as the operator of a moving flying machine remains in a fixed position, the center of gravity is an immovable, easily determinable point. The center of pressure, on the contrary, is a variable, shifting point. The position of this point alters as the direction of the wind alters, as the angle at which the air current strikes the surface of the aero-curve alters; in brief, the position of the center of pressure is determined by many constantly variable, shifting factors. To keep these two centers in a safe relation, Lillienthal and Pilcher had set the center of gravity chasing the center of pressure. The operator in the machine, as he felt the center of pressure change, moved his own position sufficiently to restore the center of gravity where it ought to be. Octave Chanute, of Chicago, an ex-president of the Western Society of Engineers, was the first to embody in a machine a mechanical device to counterbalance this travel of the center of pressure. In the Chanute machine, the tips of the wings, when struck by a gust of wind, could fold slightly backward, thus curtailing considerably the extent of shifting of the center of pressure. The Wrights seized upon the Chanute principle, but devised a new and more perfect mechanism to accomplish the result. In many instances, the movement of the operator's body necessary for balancing has been eliminated, and where not eliminated, it has been much reduced in extent.

Now that these two young Americans have finally achieved success, it is easy enough in retrospect to indicate the vital contributions which had been made by other and earlier investigators for the accomplishment of human flight. It is a coincidence that almost at the very moment at which we are writing these words the body of S. P. Langley is being laid in its grave scarcely five miles away. The publication in 1891 of Langley's report of his personal investigation into the laws of flight removed the initial question of how to get into the air from the domain of pure science to that of applied mechanics. Langley had reformed materially human knowledge of the sustaining power of the air. In the two centuries and more since the death of Sir Isaac Newton, the advance of science has been rapid and of enormous extent. Singularly enough, however, this advance had left untouched almost the interesting and important problem of aerial support. Langley demonstrated error in the teachings of Newton in two respects, each vital to the flight of man. He showed that the lifting power of the air striking a surface at a small acute angle is considerably greater than that indicated by the generally accepted Newtonian formula. Secondly, he disproved Newton's proposition that if a certain amount of power be necessary to sustain a surface stationary in the air, the same amount of power must be expended to sustain the same surface in motion. Abstract mathematics had led Newton into error. Practically, the more rapidly a surface moves through the air, the greater the upward pressure of the atmosphere upon it, and the less artificial power needed to sustain it. Briefly, Langley's chief contribution to the accomplishment of human flight was his revelation of the hitherto undreamed-of extent of the power lying dormant in the air waiting to be harnessed for the service of man.

In the work of harnessing, Otto Lillienthal hereafter will be recognized as the pioneer in indicating the method through which the success of the Wrights seems to have been won. Lillienthal began where others had left off. He abandoned the aeroplane with which Langley had experimented, and adopted the aero-curve with concave surface downward. He proved that the supporting power of the air acting beneath a surface thus curved was several times greater than when a plane of the same area was used. He was the first to demonstrate by repeated experiments that with such an aero-curve man could glide through the air like a bird.

The principle upon which the Wright machine operates is, strictly speaking, not so much flying as gliding. It is the contrivance best adapted of any yet devised by man to get the most work out of the natural elements and to depend the least upon outside power. Summer after summer for five years the Wrights experimented in their camp at Kill Devil Hills, N. C., in simply gliding through the air, until they had developed a machine which would do the best gliding possible. The latest model of their gliding machine more than quadrupled the sustaining power of any previous similar machine, and glided downward from a height at a descending angle of only five degrees, reducing the best previous record by two and a half degrees. Finally, to a machine which had demonstrated itself to be the best they could devise, when driven only by the pressure of the air upon its surfaces and the force of gravitation, they added dynamic power.

AN ELECTRIC MICROMETER FOR MEASURING THE SEVENTY-MILLIONTH PART OF AN INCH.

By the English Correspondent of Scientific American.

A remarkable achievement, of far-reaching importance to scientific investigation, has been completed by Dr. P. E. Shaw, one of the physical science lecturers of the University College of Nottingham, England, in the design of an electric micrometer by means of which measurements up to the seventy-millionth part of an inch can be accurately recorded. The successful completion of this machine has involved some five years of patient labor and experiments. Owing to the extreme delicacy and sensitiveness of the instrument, the investigations have had to be carried out in the vaults of the university, some 12 feet below the street level, during the night, when the manufactories and traffic have been completely suspended, the work being proceeded with between the hours of midnight and 4 A. M. In fact, the apparatus is so sensitive that the running of an engine at a distance of 100 yards renders it impossible to carry out fine, accurate experiments therewith, owing to the vibrations imperceptible to the human frame that are set up. Nor can demonstrations be carried out before an audience, since it is disturbed by drafts of air and dust in the atmosphere.

The electric micrometer was originally utilized for measuring the amplitude of a telephone diaphragm and it was exhibited before the British Royal Society in 1900. Since that time several improvements have been effected, each of which has rendered a smaller distance to be accurately measured than its predecessor. Dr. Shaw's investigations since that date have furthermore conclusively established the reliability of this principle of measurement, and the result of his efforts shows that a unit of 4×10^{-9} centimeter can be quite read.

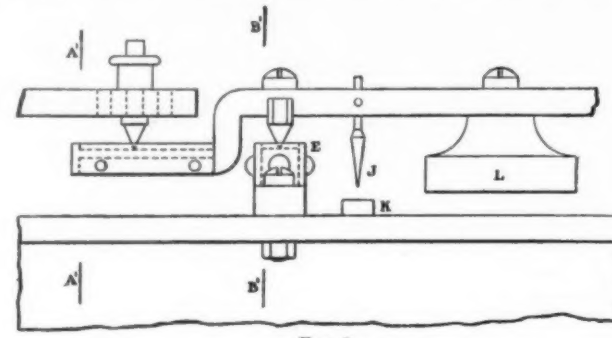


Fig. 2.

DETAILED FIGURE OF LEVER SYSTEM.

The general design of the Shaw electric micrometer may be followed from the accompanying diagrams. There is a series of six steel levers (Fig. 1, *A*) which are so fitted as to turn on the fulcra, *B*, the long arm of one lever being actuated by the short arm of the next through pointed pins, *C*. The fulcrum blocks, *D*, are made of hardened steel and have a true surface. These are attached to a massive girder, *I*, of cast iron, and are surrounded by a metal casing, *E*, which forms the sides of a bath containing oil. Each fulcrum measures one inch in width, and it rests only on two small knife edges which are at the sides, and made of hardened steel.

The short ends of the levers are fitted with a hardened steel plate, *G*, together with a small metal casing, *H*, Fig. 3, forming the sides of an oil bath. The pins, *C*, with the exception of the first in the long end of the levers, are fixed by means of a nut, and the ends of the levers are provided with three holes for these pins, so that the leverage can be varied as required. There are also pointers, *J*, Fig. 2, which are fixed to each lever, while the girder has index plates which enable the position of each lever to be fixed, or if preferred a template can be used between *J* and *D* to accomplish this end. There is also a weight, *L*, attached to each lever so that firm pressure of the levers on the blocks and on one another is insured.

The end of the long arm of the first lever is in contact by means of a polished agate plate with the point of the micrometer screw, *M*, which has twenty threads to one centimeter, and the nut of which is attached to the girder, with the usual type of free nut and spring to reduce back lash.

The lower end of the micrometer screw carries a divided wheel, *N*, and a pulley, *O*. The angular movement of the micrometer screw is ascertained by watching in a telescope (Fig. 6) the reflection in the mirror, *m*, of the undergraduated face of the wheel, *N*. The end of the last lever is fitted with a spherically ended pin of iridio-platinum. At the opposite end of the girder is attached a frame, F^1, with a spindle, R^1, carrying the fixed measuring surface, *Q*, from a plate, *F*, above, the adjustment of which can be accomplished by means of the tripod screws shown at the sides, and the binding screw, *BS*, at the top. In order to insure rigidity this frame is small and of massive proportions. The total length of the lever system is 3 feet, each lever being 6 inches long and made of ¼-inch square bar. The bed girder is 4 inches deep, of ½-inch thick material, affording a solid bed plate for the apparatus.

The instrument is inclosed in a felt-covered box, and, for the purposes of insulating it from effects of surrounding vibrations, is suspended by rubber springs from the top of a massive frame, *S*, which in turn is carried upon a pile of heavy concrete slabs, *T*, measuring 2 feet square, with rubber cushions, *U*, interposed at intervals. The tension of the rubber suspending springs is adjusted by means of weights, *W*, and in order to prevent these weights falling on the apparatus in case of breakage there are guide rails, *CB*. The total height of the apparatus is 10 feet.

The micrometer screw, *M*, is set in motion by an elastic cord driven by a pulley, *V*, which is placed on an independent table, and in order to minimize the movement set up by the working of the pulley cord, the underside of the box has a plunger, W^1, working in a dash-pot of castor oil. The vertical motion of the screw operates the system of levers, the extent of the movement being reduced by each lever in succession, and when the point, *P*, touches the first surface, *Q*, an electric circuit is completed and the telephone sounds, as it does also when *P* and *Q* separate again. The circuit shown in the diagram includes a cell, a potential divider, *R*, high-resistance telephones, and a condenser, C^1.

The *modus operandi* in setting and operating this instrument is as follows: For instance, to determine

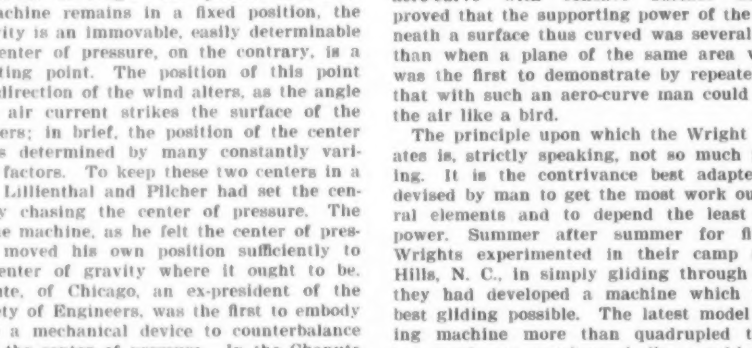


Fig. 1.

GENERAL VIEW OF MICROMETER DETECTING CIRCUIT.

the magnetic expansion of the rod, R^1 (Fig. 1), that is, the increase in its longitudinal expansion when a known current is transmitted through a solenoid of which R^1 is the core, the plate, Q, is first unscrewed, and, together with the last lever, which carries P, is removed and polished with dry rouge on a wash leather, and finally cleaned with a dry, clean wash leather. The plate and lever are then replaced. P and Q have now to be brought just into contact, which, it may be pointed out, is a very delicate adjustment. The telephone receiver is then held to the ear and

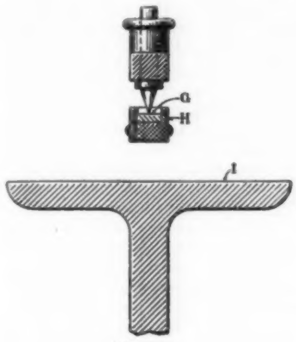


FIG. 3.

the three tripod screws on the frame, F^1, as well as the binding screw on the top of this frame, are adjusted. The former have an upward motion producing level while the latter works down. With P and Q just in contact the whole system can be obtained quite rigid, as the sounding of the telephone testifies. The contact which is thus completed is very rough. P and Q have now to be brought into *bare* contact and this is carried out by means of the pulley, V, winding the pulley cord and turning the micrometer screw, M, until the telephone sounds again. The exact position of contact is now obtained. There will be a steady creep of the contact position for a considerable time after the covers are put on. Accurate work, however, can be carried out when the temperature equilibrium is established, which occupies from 15 minutes upward. The readings of the wheel, N, are followed by means of the telescope and mirror, and the indications thereon corresponding to the contact make-and-break are noted. The magnetic field on R^1 is then changed by known amounts, and the corresponding changes in the contact positions of P and Q observed. If the joint leverage is 1,000/1, and the screw pitch be 1/20 centimeter with 500 graduations on the wheel, N, then the unit of measurement will be 10^{-7} centimeter.

Calibration can be carried out by measuring all the lever arms and multiplying the joint leverage into the unit of the micrometer screw, or the calculation may be carried out by optical interference, which is the better process. In this case the plate, Q, and the spindle, R, are removed, and a glass plate mounted with a worked surface downward in their stead. A convex lens of small curvature is placed on the top of the pin, P. Newton's rings can be produced in the usual way between the plate and the upper lens surfaces. Sodium light is used and the rings are watched with a microscope. On moving the micrometer screw up and down, the pin, P, rises and the rings grow from, or contract into, the center respectively. Readings of the screw head are taken for every ten rings passing one point, and the unit is at once calculated.

The levers are bent for four reasons in order that (1) the turning edges of the fulcra, (2) the contact point of each lever on the next, (3) the contact of screw on the first lever, and (4) the contact P and Q where the measurements are made, should all lie in one horizontal plane. Consequently, when the actuating screw works up or down by a small amount, there is a normal displacement at every contact surface and no scraping of one surface on another. If only these small movements are made, end strain or actual sliding, conducive to sudden alteration in leverage and jerky working, are avoided.

Certain strains in the levers are, however, unavoidable, but owing to the system adopted in the design of the instrument no large stress is applied at any particular point. The arrangement of the levers conspires to minification, each long arm resting on the next short arm and moved therewith. The actual pressures between the fulcra and the blocks, and between lever and lever, have alternate maxima and minima from one end of the system to the other, the greatest differences being at the left end of the system. All strains, however, are attributable to constant gravitation stresses, and owing to the well-oiled system of contacts adopted it is not considered that irregular strains can arise from simple measurement operations. Owing to the conspicuous success that has attended the manipulation of the mechanism, the strains are evidently of an exceedingly regular nature, and it is apparent that each link in the series adds appreciable accuracy and sensitiveness.

With regard to longitudinal displacements of the levers these latter are allowed three degrees of freedom—a rotation on a vertical axis, a translation across the girder, and a translation along the girder. In each case the play is very minute, but it is desirable that the levers should have freedom without using it. The levers are equispaced, since if the small arms were the same length in each lever, a small longitudinal displacement of any lever, with the exception of the first and last, does not seriously change the total leverage. For instance suppose the second lever (Fig. 1) be moved a small distance to the right, the first lever will gain and the second lever will lose leverage in the same ratio. If, however, the movement be continued, the short arms of the two levers being now unequal, the first lever gains leverage in greater ratio than the second loses it. The first and last levers are exceptions; if the first lever move by a small amount to the right it alone loses leverage. If the last lever move to the right the fifth lever alone gains leverage. Consequently the first and last levers must not be permitted to move longitudinally during an experiment,

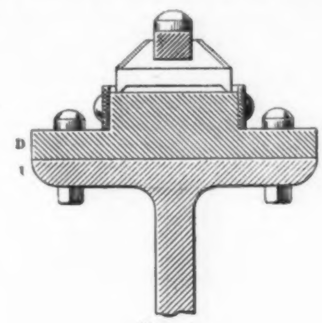


FIG. 4.

and in work where a high degree of accuracy is being carried out the levers must be frequently set in those places for which the instrument has been calibrated.

The oil baths perform two valuable functions. In the first place they serve to lessen the jerk which might arise from the levers sliding, and secondly they preserve the contacts from dust and atmospheric oxidation. Of the thirteen contacts comprised in the lever system only two are exposed to the air—the first and the last. If particles of dust be permitted to fall upon the contact surfaces there is a possibility of their working into the contact, producing serious error in the calculations, especially at the left end of the instrument. The dust, however, falls upon the surface of the oil, and remains there, leaving the immersed contacts below quite clean.

Owing to the elaborate system of insulating the appliance, ground tremors cannot easily reach the micrometer, except by ascending through the massive cement slabs interleaved with cushions of rubber, then passing to the top of the frame, S, and descending the weighted rubber cords, or by passing along the rubber pulley-cords. The latter, however, are too light and lax to transmit such tremors as will affect the suspended body, which weighs about 80 pounds. Measurable tremors have only been observed to reach the instrument on rare occasions, but for the finest work where high degrees of accuracy are essential the experiments are conducted after midnight.

So far as thermal expansions are concerned, so long as the expansion is in the direction of length of the instrument they can be ignored; while, on the other hand, expansion perpendicular to the levers introduces a large element of error. To minimize such contingencies the cage F^1, the spindle, R^1, pin, P, lever pins, C, and the fulcra, B, are made of invar. Vertical expansions, however, diminish in importance in passing from the cage, F^1, to the opposite end of the instrument, so that thermal expansion in the screw and the last lever pin can be ignored. When commencing a new set of measurements the micrometer is uncovered and the contacts, P and Q, cleaned. When the cover is replaced thermal expansion will be observed in "creeping" of the contact, and for the most delicate work sixty minutes or more will be required for the establishment of the temperature equilibrium.

Several metals, such as steel, iron, platinum, copper, and carbon, have been tested for the contacts, P and Q, but up to the present iridio-platinum has given the best results. A high polish for the purpose of sharp readings to the contacts is essential, accomplished with dry rouge on wash leather. Furthermore, the ordinary use of the surfaces involving frequent make-and-break damages them in about one hour under continuous use and the readings become uncertain. Some authorities have pointed out the fact that as the surfaces, P and Q, approach one another, having a potential difference of about one volt, an arc will be formed between them before they meet, and that this sparking constitutes an irregular factor, and a source of uncertainty in the finest experiments. Probably this arcing occurs, but experience has demonstrated that it is not irregular within experimental limits since the readings of the instrument are very consistent.

This apparatus is applicable to a variety of measurements where a high degree of exactitude is required, and has already been practically utilized in the improvement of telephones such as the diaphragm movements and the amplitude of the least audible sound. In this direction of experimental scientific investigation it has measured movements of only one forty-millionth part of an inch. It can also be employed for the measurement of the expansion of iron, steel, nickel, and non-magnetic bodies when subject to changes of magnetic field. As a coherer it possesses many advantages owing to the fact that the two contact points can be brought to molecular distance apart, without touching, and thus constituting a coherer of extreme delicacy, possible of considerable adjustment; also for testing thermal expansibility and the Newtonian constant by the measurement of the movements of a pendulum from the vertical under the attraction of a large mass.

The Royal Society of Great Britain has evinced the greatest interest in Dr. Shaw's experiments, and has on two occasions made appropriations from its funds for the furtherance of his investigations and the perfection of his machine. The professor is still continuing his work owing to the far-reaching effects that his instrument has produced, and the delicacy of measurements of a fine degree, which has hitherto been impossible with such accuracy. By means of the further developments upon which he is now engaged he is hopeful of being able to measure more minute distances and quantities than the seventy-millionth part of an inch which is now possible with the appliance.

THE HISTORY OF DIFFRACTION.

THOUGH diffraction dates back to Grimaldi (1665) and was well known to Newton (1704), the first correct though crude interpretation of the phenomenon is due to Young (1802, 1804). Independently Fresnel (1815) in his original work devised similar explanations, but later (1818, 1819, 1826) gave a more rational theory in terms of Huyghens's principle, which he was the first to adequately interpret. Fresnel showed that all points of a wave front are concerned in producing diffraction, though the ultimate critical analysis was left to Stokes (1849).

In 1822 Fraunhofer published his remarkable paper, in which, among other inventions, he introduced the grating into science. Zone plates were studied by Cornu (1875) and by Soret (1875). Rowland's concave grating appeared in 1881. Michelson's echelon spectrometer in 1899.

The theory of gratings and other diffraction phenomena was exhaustively treated by Schwerd (1837). Babinet established the principle bearing his name in 1837. Subsequent developments were in part concerned with the improvement of Fresnel's method of computation, in part with a more rigorous treatment of the theory of diffraction. Stokes (1850, 1852) gave the first account of the polarization accompanying diffraction, and thereafter Rayleigh (1871) and many others, including Kirchhoff (1882, 1883), profoundly modified the classic treatment. Airy (1834, 1838) and others elaborately examined the diffraction due to a

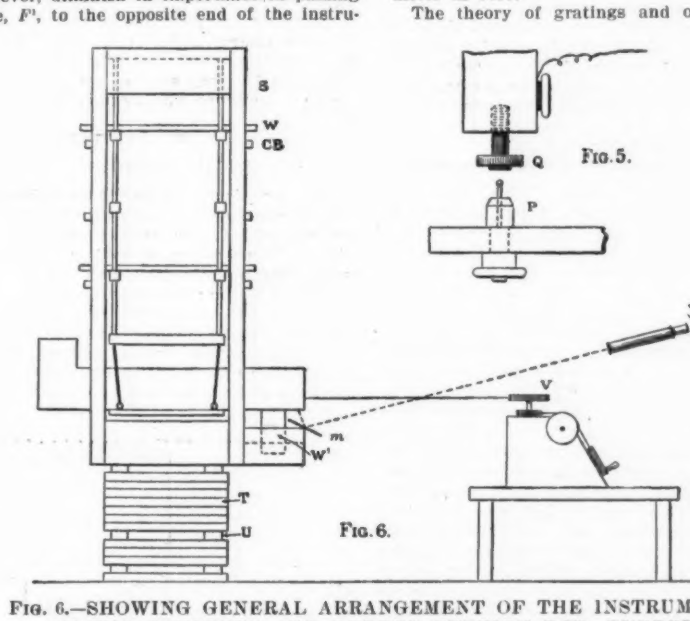


FIG. 5.

FIG. 6.

FIG. 6.—SHOWING GENERAL ARRANGEMENT OF THE INSTRUMENT ON THE CONCRETE AND RUBBER CUSHION BED, RUBBER PULLEYS, AND TELESCOPE FOR READING.

point source in view of its important bearing on the efficiency of optical instruments.

A unique development of diffraction is the phenomenon of scattering propounded by Rayleigh (1871) in his dynamics of the blue sky. This great theory which Rayleigh has repeatedly improved (1881, et seq.) has since superseded all other relevant explanations.

Correspondence.

NEW USES OF PEAT AND FOREST PRODUCTS IN GERMANY.

To the Editor of SCIENTIFIC AMERICAN SUPPLEMENT:

Under the above heading, Mr. William Mayner, in SUPPLEMENT No. 1571, issue of February 10, 1906, p. 25176, has published a report on certain articles contributed by Prof. Wislicenus at the School of Forestry at Tharandt, Germany. In the latter part of his article, Mr. Mayner describes also the manufacture of sugar and spirit from sawdust by Dr. Roth's process. In connection with these statements, I would first point out that Roth's process does not contain any patentable innovation at all, and that it is neither in operation nor capable of being worked on a commercial scale. I have already had the Hungarian patent annulled, and will have any further patent annulled as soon as I shall have any opportunity of doing so. Prof. Wislicenus, having read a paper on the ground of direct statements given to him by Dr. Roth, commercial chemist, and published it in the form of a brochure, retracted his statements in October, 1904, in several chemical papers in Germany (Zeitschrift für angewandte Chemie, Chemiker Zeitung, and others). Prof. Wislicenus was compelled to do so because Dr. Roth had given him some misleading statements also in respect to my patented process for producing alcohol from sawdust. Having sent a copy of Prof. Wislicenus's retraction to the editor of this journal, I wish to give here merely the following extract of same:

"The lecture on spirit from waste wood appeared some time ago as a reprint of the report of the Saxon Forest Society of 1904. This gave occasion to Mr. Classen to call my attention to an error which, with best thanks to Geheimrat Classen, I wish hereby to correct. In writing my paper, I underestimated the results obtained with the patented Classen process, because the particulars of the Roth process furnished to me in writing and personally were wrong and because these errors were directly caused by incorrect data in Roth's application. By remitting authentic reports to me, Mr. Classen convinced me of the fact that the yield of absolute alcohol stated by him in his letters patent was also obtained in working on a commercial scale, this yield not being 3 liters, as I said in my lecture, but from 12 to 14 liters. Dr. Roth states the yield by his process to be 15 to 17 liters of alcohol of 80 per cent, which corresponds to about 12 or 13 liters of absolute alcohol. I wish to point out that the avowed object of my paper was merely the description of the beginnings of new industrial developments, more from the summarizing standpoint of a reporter than on the ground of my own practice. What I pointed out with some reserve with reference to the great future importance of the manufacture of alcohol from wood therefore stands, but what has been said must only be applied to Classen's process."

The above few remarks will be sufficient, I think, to state the true bearing of the case; in addition I would further state that the pretended yield obtained by Roth's process was obtained only by tests made on a very small scale from a few hundred grammes of sawdust.

PROF. DR. CLASSEN.

Aix-la-Chapelle, Germany, March 17, 1906.

THE CERVERA WIRELESS TELEGRAPH.

FOR about a year past, the scientific press of Spain and other countries has been speaking at some length of the system of wireless telegraphy of the Spanish commander Jules Cervera, and of the numerous experiments made in Spain, under the auspices of the war department of that country, between Ceuta (Africa) and Tarifa (Spain), a distance of 21 miles.

Several very interesting things have been said about the Cervera system. Thus, for example, the political press of the country of Alfonso XIII. has claimed that Commander Cervera has been able to correspond at a speed of twenty-four words a minute, which would mean that the Spanish system was, at least from the viewpoint of speed, superior to the English system of Marconi. Finally, not many days ago, it was announced in Spain that a company had been formed in that country for the exploitation of the system of Cervera, who had succeeded in practically applying the Hughes apparatus to telegraphy without wires, and in thus obtaining speed of transmission never before obtained nor even dreamed of.

While awaiting a certain proof of the realization of so many marvels and the results of the very-long-distance experiments, we shall be content to devote a little space to a description of the arrangements that Cervera employed between Ceuta and Tarifa, where masts of the respective heights of 167 and 180 feet were erected.

The Cervera transmitter (Fig. 1) is similar to the one described by Capt. Della Riccia in the Rivista d'Artiglieria e Genio in September, 1897. A manipulator and a battery of accumulators or a continuous current dynamo are put in circuit with the primary of an induction coil provided with an interrupter with a condenser in derivation. For the source of energy and the interrupter there may be substituted an alternating current machine. The secondary terminals of the induction coil end at the balls of an oscillator connected respectively, through condensers, with the ground and the sprits of the mast. The object of the condensers is to increase the capacity of the system and consequently the energy of discharge given by CV^2, where C is the capacity, and V the difference of potential. The connection with the ground in the Cervera transmitter arrangement is not even necessary, nor is it indispensable in other systems, because the rôle of the earth is that of a capacity. It may be replaced by other arrangements. The doing away with it, however, diminishes the range of the communications, although it does not affect the transmission.

The Cervera transmitter is characterized by two special and equally interesting manipulators. The first

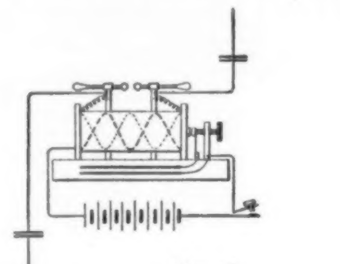


FIG. 1.—CERVERA TRANSMITTER.

is a keyboard manipulator. Upon pressing with the finger the ebonite button or key that carries the letter or sign to be transmitted, there are produced dots or dashes that reprint such letter or sign in the Morse alphabet. The keyboard is manipulated after the manner of that of writing machines. Commander Cervera has recently employed a manipulator in which he absolutely suppresses the breakage sparks of the current. This is done by grounding, in the one hand directly, and in the other through a condenser, the points at which the interruption of the current takes place. The Cervera receiver (Fig. 2) closely resembles the last form of the Marconi one, but, in our opinion, is more complicated. The mast-sprit is connected with the earth through the primary of a small transformer of which the terminals of the secondary (divided in the center by a condenser) end at the electrodes of the coherer. A battery in the circuit of the latter actuates a relay that closes the circuit of a second relay, which has four rôles to perform, viz., (1) to actuate a Morse apparatus; (2) to actuate a striker for decohering the sensitive tube; (3) to interrupt the current of the battery of the coherer (a rôle appropriated to the armature of the striker); and (4) to interrupt the circuit of an electro-magnet that regulates by magnetic cohesion (and, consequently, by the pressure of the metal filings) the sensitiveness of the radio-conductor. It is to be remarked that each of the three parts—Morse apparatus, strikers, and electro-magnet—has a source of electricity apart, which, with the battery of the coherer and that of the relay, makes five electric sources in the Cervera receiver. Such being the case, it is difficult to admit, at least to explain, what the daily papers have recently announced, viz., that with the Cervera system it has been found possible to correspond at a speed of twenty-four words a minute, while with the Marconi system, for example, the speed is on an average ten words of five letters.—E. Guarini, in La Nature.

CURIOUS DECOMPOSITION OF LIGHT.*

WHEN a visual ray passes near the plane of separation of certain superposed liquids, rainbow colors, it is known, will appear, caused by the decomposition of light. These colors, variable according to the angle of incidence of the look with reference to this plane, are those of the solar spectrum.

The mixture of two liquids, glycerine and oil of turpentine, constitute a curious mode of decomposition of white light, which it seems interesting to notice. These two liquids are completely insoluble in each other, so that the effect of agitation is limited to the greater or

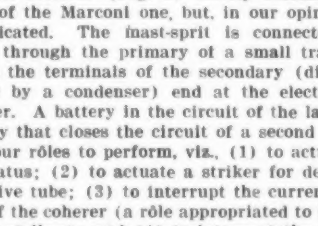


FIG. 2.—CERVERA RECEIVER.

less division of one in the mass of the other; that is, to emulsionizing them. I give the preference to the officinal glycerine, with density 1.242.

A quantity of these liquids is introduced in a test tube, say 15 cubic centimeters of glycerine and 3 or 4 cubic centimeters of oil of turpentine. Energetic shaking divides the oil into an infinite number of globules, which, after a few minutes of repose, collect in the upper part of the liquid column. So great is their transparency, it might be supposed that the two liquids are absolutely separated. This, however, is not the case; a little attention shows, even to the naked eye, small drops extremely divided, and the microscopic examination removes all doubt. The finest of the globules may even remain in suspension several days.

If at this time the separations of the panes of glass in a window are examined through the tube, instead of appearing black, that is, deprived of light, they will be found to be blue; also, the part not lighted of all objects looked at in the same way will be seen colored blue. Black writing and printing on white paper also appear of the same color. On looking attentively at the contours of the objects examined, they appear of a yellowish tint, the complementary color of blue.

These tints are not the only ones that such a mixture will give. When the test tube is placed in a water bath with the temperature raised to 70 deg. C., and the liquids examined after separation and clarification, the objects previously colored blue will appear green; gradually, and in consequence of cooling, they assume colorations, successively green, yellow, orange, red, violet, indigo, and finally blue, i. e., the colors of the spectrum, but in an order slightly different.

In the same way as for the blue, the color complementary of the one on the dark parts of the objects may be distinguished on the contours, as blue more or less greenish, then green more or less yellowish, and finally yellow. This dispersion in two tints of white light is probably occasioned by the difference of refrangibility of the liquids tested.

Instead of having recourse to the officinal glycerine, glycerine of 30 deg. Baumé may be employed; in this case with certain kinds of oils the green coloration of objects may be obtained directly, cold. To thus secure the whole range of colors without the aid of heat, it is sufficient to add to the mixture of glycerine and oil of turpentine water drop by drop, while shaking.

In place of oil of turpentine, the oils of thyme, eucalyptus, bergamot, and others may be made use of. The peculiar feature of this decomposition of light is that while lenses not achromatic allow of seeing objects not receiving the light as black, and giving to their contours two different and complementary colorations, the one above and the other below, or one on their right and the other on their left, in this case the dark parts are seen colored, and all their contours appear uniformly of the color complementary of the first.

* From the French of M. Mansier in the Repertoire de Pharmacie.

TUPELO AND THE SEASONING PROBLEM.

SEVERAL causes have of late brought tupelo into more prominence than it formerly enjoyed. The first of these is the general need of utilizing all possible species, which is introducing upon the market various trees which had no standing so long as the better known kinds were freely obtainable. A second cause is that the tree is found in good quantity in mixture with cypress, which is now receiving so much attention from lumbermen, and the costs of lumbering cypress are so heavy that if tupelo could be lumbered with it at a profit this would mean so much added return to the holder of cypress stumpage. The excellence of the wood of tupelo is also in its favor, but hitherto this has been offset by the difficulties encountered in handling the lumber—difficulties which have not been wholly overcome. In this respect tupelo is much like red gum, now a leading wood, which found a ready market only recently, after special study had shown that right methods of handling obviated certain defects.

Tupelo received its scientific name of *Nyssa aquatica*, or "water gum," because of its ability to thrive in wet situations. Like cypress, it is proof against floods which would kill other species, and its distribution coincides very largely with that of cypress. The best grades of the wood are very similar to that of yellow poplar; they have a fine, uniform texture, are soft and workable, and will take stain well. Such qualities signify a usefulness which must lend the wood increased market value if its tendency to warp, twist, and "stick-rot" during seasoning can be controlled. Up to the present, however, the requirements of tupelo in seasoning have been but little studied by the manufacturer. It has not received the degree of attention which is due to wood of such adaptability.

When lumber is piled for drying, much depends upon the proper separation of the layers or "courses," to allow the air to circulate. This is secured by inserting cross-sticks, which keep the boards from touching one another. Many woods may be piled with but little care and yet dry straight and sound, but tupelo must be piled evenly and so as to secure straight-laid boards, even at the cost of more time and pains. It is a common practice to use for cross-sticks wood which has been irregularly sawed, so that the boards are not held flat in the courses. Tupelo will not dry well with this treatment. Furthermore, where the cross-sticks rest on the boards, tupelo is inclined to rot or stain, and before air drying can be brought to practical success this difficulty also must be overcome.

Kiln drying is, of course, commonly used by manufacturers of cypress lumber, but tupelo needs a different treatment in kiln drying from that given cypress, and cypress manufacturers, sure of a market for their cypress, and with their kilns constantly monopolized by it, have little inducement to experiment with the less understood tupelo. Nevertheless, altered kiln-drying methods will doubtless be used for tupelo in due time.

In the effort to improve both the air drying and kiln drying of tupelo, the Forest Service is experimenting to show how the lumber may best be handled. There

can be little doubt that the results will add another tree to the list of southern species which scientific treatment has placed within the class of popular market woods.

CONTEMPORARY ELECTRICAL SCIENCE.*

Mechanism of Radiation.—H. A. Lorentz attacks the main outstanding difficulty of the electron theory in a paper "On the Radiation of Heat in a System of Bodies having a Uniform Temperature." A body in a state of thermal equilibrium with its surroundings absorbs as much heat as it emits. If the emission of heat is due to the revolution or vibration of electrons, these will be subject to a severe damping, and in order to maintain their motion, a considerable E. M. F. will be necessary. The author proceeds to calculate the amount of this E. M. F. In view of the formidable mathematical difficulties involved he has recourse to a number of artifices. He substitutes for the simple vectors **E**, **B**, **H**, and **C** certain complex vectors, all of which are harmonic functions of the time with the frequency n. Thus they contain the factor e^{int}, and a differentiation with respect to time amounts to a multiplication by in. He arrives at an important new theorem: If an electromotive action applied at a point, P, in the direction h produces at a point, P', a current whose component in an arbitrarily-chosen direction h' has a certain amplitude and phase, then an equal electromotive action taking place at the point P' in the direction h' will produce a current in P whose component in the direction h has exactly the same amplitude and phase. This theorem enables him to calculate the amplitude of the E. M. F. to be applied to an element of volume s in order to make it emit radiation obeying Kirchhoff's law. In any given direction this amplitude is of the form

$$\frac{4\pi c}{n}\sqrt{\frac{2k\alpha\,dn}{s}},$$

where c is the velocity of light, and n the frequency. The author does not proceed for the present to the consideration of individual molecules, his object being to discover a possible mechanism of absorption and emission in the elements of volume of a substance.—H. A. Lorentz, Proceedings of the Royal Academy of Sciences, Amsterdam, November 22, 1905.

Inertia and Radiation.—A. Einstein is led to some conclusions of fundamental importance by a consideration of the manner in which the velocity of light enters into several physical quantities where its influence was hitherto unsuspected. The simple operation of measuring the length of a rod in motion gives different results accordingly as it is measured by an operator at rest or by an operator moving with the rod. Problems involving moving bodies can, therefore, only be rigidly solved by referring them to co-ordinate axes moving with them and then transforming the results to axes at rest. In doing so the author employs what he calls the "principle of relativity," which he formulates thus: The laws according to which the states of physical systems in parallel and uniform translational motion with respect to each other, and the changes of state, may be referred to either of them. The length of a rod moving with the moving system, with its axis in the direction of motion, will, when measured in the system at rest and in the moving system, differ in the ratio $1 : \sqrt{1-(v/V)^2}$ in the two systems. This is Lorentz's well-known ratio. A timepiece moved away from another with which it agrees, and taken through any path (say round the earth) in the time t, back to its original place, will be in arrear by $\frac{1}{2}t\left(\frac{v}{V}\right)^2$ seconds, v being its velocity, and V the velocity of light. But the most striking conclusion is that the inertia or mass of any material body, just like the mass of the electron, depends upon its internal energy. If a body gives out an amount of energy L in the shape of radiation, its mass is diminished by the amount L/V^2. But the species of energy does not really matter. Whatever energy is given out diminishes the mass and *vice versa*. The mass of a body is a measure of its internal energy. For every erg of energy given out it loses $\frac{1}{V^2} = \frac{1}{9\times 10^{20}}$ grammes of mass, so that 1 gramme of mass would represent 9×10^{20} ergs. The amount of energy given out by bodies is as a rule quite insufficient to affect their mass perceptibly. But there is just a chance that the radio-active bodies, which emit comparatively enormous quantities of energy, may furnish an experimental test of these conclusions.—A. Einstein, Annalen der Physik, No. 11, 1905.

Deflection of α-Rays.—A. S. Mackenzie has measured from the deviations of a beam of α-rays in a magnetic and in an electrostatic field the value of the velocity v, and of the ratio e/m for the rays from radium and polonium, in order to search for evidence of a change in any of the quantities v, e, or m as the rays travel in an ordinarily good vacuum. To be able to take both eye observations and photographic records, the author used a "scintilloscope" consisting of a zinc sulphide screen of thin glass, against which the film of the photographic plate could be pressed from the outside. He found the electric dispersion of the beam much smaller than the magnetic dispersion, and amounting to only 10 per cent of the deviation. If there were different kinds of particles sent out by the radium, the lesser dispersion in the electric field would be explained if the energies of the different kinds of particles were much more nearly the same than their momenta, as these are the physical quantities involved in the electric and magnetic deviation respectively. The slowest rays from the radium examined have a velocity of 1.18×10^9 centimeters per second, and the fastest 1.74×10^9. The average is about one-twentieth of the velocity of light. The ratio e/m is 4.6×10^3 instead of the 6.2×10^3 of Rutherford and the 10^4 of the hydrogen atom. If the charge is the same as that of the hydrogen atom, the mass of the α-particle must be about 2.2 hydrogen atoms, or something like the hydrogen molecule. Since molecules can hardly be assumed to be present, it is most likely that both hydrogen and helium atoms are given out by the radium, and that their energies are about the same, so as to give a small electric dispersion. As regards polonium, the average velocity of the α-particles expelled by it is greater than that of the same particles from radium, but none of them attain the high maximum velocity of the radium particles.—A. S. Mackenzie, Philosophical Magazine, November, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

ENGINEERING NOTES.

Many non-automatic manually controlled machines can be replaced by semi-automatic ones, so that one man can attend to two, three, or more of these machines; and, one step farther, many non-automatic or semi-automatic machines can be replaced by automatic ones, for which the only attention required is the intermittent feeding of a new bar from which the screws, nuts, bolts, etc., are automatically turned out. But, in addition, besides the economy in it, there is the advantage of obtaining uniformity of product, and greater degree of accuracy. It is quite possible, however, to overstep the mark in installing automatic or semi-automatic machines, especially the former. They are only a paying investment when the number of pieces of one kind is large, so that the time taken to set the mechanism is small compared to the time the machine will be in operation. It is the balancing of capital and interest against saving in attendance.

The constant necessity for re-boring, application of bushings, and renewals of cylinders as a whole, as well as of their detailed parts, in connection with large compound and simple cylinder types of locomotives, has been very prominent and expensive. Much of this cost can be attributed to incorrect proportions in general and detailed design; improper material, foundry practice and workmanship; restricted and badly arranged passages for the prompt release of exhaust steam and water of condensation; insufficient and defective means of lubrication; defective packing to high pressure piston heads, allowing accumulation of excessive pressures in low pressure cylinders and permitting the locomotives to be generally run in the service with defective parts and improperly operated. It is a difficult matter to combine in one casting a cylinder of such metal as will provide for the strength that is required, as well as for suitable wearing purposes, and the bushing of the wearing parts of all cylinders, when they are newly applied, is recommended to improve results and to facilitate maintenance.

In his letter to the Senate and House of Representatives, President Roosevelt sums up the respective merits of a sea-level and a locked canal at Panama, as follows: "The sea-level canal would be slightly less exposed to damage in the event of war, the running expenses, apart from the heavy cost of interest on the amount employed to build it, would be less, and for small ships the time of transit would probably be less. On the other hand, the lock canal at a level of 80 feet or thereabout would not cost more than half as much to build, and could be built in about half the time, while there would be very much less risk connected with building it, and for large ships the transit would be quicker; while taking into account the interest on the amount saved in building, the actual cost of maintenance would be less. After being built, it would be easier to enlarge the lock canal than the sea-level canal. Moreover, what has been actually demonstrated in making and operating the great lock canal, the Soo, a more important artery of traffic than the great sea-level canal, the Suez, goes to support the opinion of the minority of the Consulting Board of Engineers and of the majority of the Isthmian Canal Commission, as to the superior safety, feasibility, and desirability of building a lock canal at Panama."

It appears from several experiments which R. E. Mathot has made on double-acting Otto cycle engines that the quantity of circulation water required for the different parts is as follows:

Per B. H. P.-hour for engines of 200 to 1,000 H. P.

	Gallons.
Cylinders, cylinder ends and stuffing boxes..	4 to 5¼
Pistons, piston-rods	1¾ to 2¾
Valve-boxes and seats, and exhaust valves..	⅞ to 1⅜
Or a total of	6⅝ to 9⅜

These figures imply water admitted on an average of 12 deg. to 15 deg. C. (53.6 deg. to 59 deg. F.) and leaving the cylinder jackets at 25 deg. to 35 deg. C. (77 deg. to 95 deg. F.), the pistons at 35 deg. to 40 deg. C. (95 deg. to 104 deg. F.), and the valve seats and boxes at 45 deg. C. (113 deg. F.) on an average. An engine of 1,000 horse-power, of the two-cylinder double-acting type, would therefore require about 40 cubic meters (8,900 gallons) of cooling water per hour. As this is an excessive quantity which is not available at every works recourse is commonly had to the use of cooling towers which reduce the consumption of water to about 0.5 liter (1-9 gallon) per horse-power-hour, absorbed by evaporation. This method has also the appreciable advantage over the ordinary water circulation of eliminating, owing to the continuous use of the same water, the deposit of calcareous incrustations. Without possessing in the case of gas-engines the same dangers as in steam boilers, lime scale and deposits still constitute a drawback. They obstruct the pipes and passages, and impede the regular cooling by coating (with a non-conducting material) the metal at the places where a high temperature is most injurious. At the parts cast with a double jacket, and which cannot be dismantled, it is necessary to arrange large openings covered by bolted lids in order to enable free access to the inside to remove these deposits.

SCIENCE NOTES.

While bacteriology has grown to gigantic proportions as a medical science and has revolutionized every branch of medical practice, its effect upon the teaching profession has been largely to excite skepticism and engender ridicule. The idea is unfortunately prevalent that bacteriology is one of the very difficult, most exacting of the advanced studies of the university. The fact is that the essential technique of bacteriology can be mastered, in two weeks' time, by any wide-awake lad of twelve, and its truths redemonstrated by the most unskilled pupil of high school age.

In the world of life the naturalist describes those forms which persist as species; similarly the physicist speaks of stable configurations or modes of motion of matter; and the politician speaks of states. The idea at the base of all these conceptions is that of stability, or the power of resisting disintegration. In other words, the degree of persistence or permanence of a species, of a configuration of matter, or of a state depends on the perfection of its adaptation to its surrounding conditions. If we trace the history of a state we find the degree of its stability gradually changing, slowly rising to a maximum, and then slowly declining. When it falls to nothing a revolution ensues, and a new form of government is established. The new mode of motion or government has at first but slight stability, but it gradually acquires strength and permanence, until in its turn the slow decay of stability leads on to a new revolution.

In the early stages of civilization man calmly divided the universe into two parts—himself and nature. Regarding himself as the more important element, to himself he gave his chief attention. Consequently we find that literature and philosophy—man's doings, his hopes, his beliefs, and his achievements—held first place in the estimation of ancient peoples. The true appreciation of nature is recent; the scientific spirit is a birth of yesterday; yet it is by far the greatest force now influencing civilization. Its influence is felt not only in the professions and the sciences, but in the arts, in trade and commerce, even to the uttermost avenues and by-ways of life. Whether our tastes be artistic or scientific, philosophic or æsthetic, literary or mathematical, we should know that the age in which we live is a scientific age, that the great forces of society, as well as of nature, are controlled by scientific principles; in fine, our entire environment is a result of the scientific spirit.

It has been shown that the mosaic disease of tobacco and other similar diseases are accompanied by certain oxidase ferments which appear to prevent the digestion of reserve food. The ferment is developed in the growing parts of the plant, it may be transferred from plant to plant, and on the decay of the diseased organism, it is supposed to be set free in the soil. It is believed that it is then capable of diosmosis and infection of the young seedling. While it cannot be shown at present that the enzyme is beyond all question the direct cause of the disease, this field of work is certainly one which might yield most interesting results. In this connection it may be stated that peach yellows and several other important contagious diseases are believed to be of somewhat similar nature. It is also claimed that the keeping qualities of fruits may bear a certain relation to the amount of enzymes present at the time of storage; and, therefore, a knowledge of the time and conditions of the production of such enzymes would have great economic value.

Rear Admiral Sir W. J. L. Wharton has compared with their true position the positions of thirty-one of what may be taken as the fundamental points in the world as given in the larger scaled French charts of 1755, from which the general one is drawn, and he finds that on an average they are forty-eight miles in error. The errors vary from 160 miles to 2 miles. If the delineation of the coast lines between be considered, the inaccuracies are very much greater. Very shortly after this date more accurate determinations began to be made. The method of lunar distances was perfected and facilitated by tables published in the various astronomical "ephemerides," and seamen and explorers commenced to make use of it. Still, the observation required constant practice, and the calculation, unless constantly made, was laborious, and it was used with complete success by the few. The great Capt. Cook, who may be looked upon as the father of modern methods of surveying, did much to show the value of this method; but the chronometer came into use shortly after, and the principal advance in exact mapping was made by its aid. There is a vast amount yet to be done for geography. Until we possess publications to which we can turn for full information on

all geographical aspects of things on this globe of ours, there is work to be done. Seeing that our present publications are only now beginning to be worthy of being considered trustworthy for the very small amount of knowledge that we already possess, geographical work in all its branches is practically never-ending.

TRADE NOTES AND FORMULÆ.

Toilet Water.—1 part of rose water, 50 of borax, and 5 of camphor. This will always keep its freshness, and has an invigorating effect upon the skin.—Neueste Erfindungen und Erfahrungen.

Glass Staircases.—A new, or at least neglected, use of wire-glass is suggested by Scharnitzauer and Obwalt, the managers of the large glass works at St. Gobain in southern France. By its use for stairs, light would be given to spaces usually dark, such as under the stairs and in cellars. In case of fire the glass stairs are safer than wooden ones, since they do not burn, and even if cracked by heat, hold together. Besides this, they do not develop smoke, which so often bars exit. In this respect they rank with the concrete stairs.

Effect of the Ultra-Violet Rays upon Baldness.—Prof. Kronmayer, in the Monatsheft für praktische Dermatologie, describes his light-treatment for falling hair and baldness. Of thirty-two cases where every other remedy had failed, in some of which the head was entirely bare, twenty-seven were cured. Not only hair, but eyebrows and beard, which in some cases had been lost, were promptly restored by the effect of the light, which seems the more remarkable, as in most cases the trouble was of many years' standing.

Goat's Milk Cheese.—Good goat's milk cheese is made as follows: Warm 20 quarts of milk and coagulate it with rennet, either the powder or extract. Separate the curds from the whey in a colander. After a few days the dry curd may be shaped into larger or smaller cheeses, the former only salted, the latter containing salt and caraway seed. The cheeses must be turned every day, and sprinkled with salt, and any mold removed. After a few days they may be put away on shelves to ripen, and left several weeks. Pure goat's milk cheese should be firm and solid all the way through. Twenty quarts of milk will make about 4 pounds of cheese.—Neueste Erf. u. Erf.

A Stain for Floors.—The Pharmazeutische Zeitung, of Berlin, gives the following receipt for a floor stain: Boil 25 parts, by weight, of fustic and 12 parts of Brazil wood with 2,400 parts of soapmakers' lye and 12 grammes of potash, until the liquid measures about 12 quarts. Dissolve in it, while warm, 30 parts of annatto and 75 of wax, and stir until cold. There will be a sufficient quantity of the brownish red stain to keep the floor of a large room in good order for a year. The floor should be swept with a brush broom daily, and wiped up twice a week with a damp cloth, applying the stain, when necessary, to places where there is much wear, and rubbing it in with a hard brush. Every six weeks put the stain all over the floor, and brush it in well.—Neueste Erf. u. Erf.

Soft Tin Solder.—Soft tin solder is usually made from a mixture of tin and lead, the content of lead being gaged by the melting point of the metal to be soldered. The percentage of lead lies as a rule between 33 per cent and 66 per cent. Solder containing over 37 per cent of lead is difficult of fusion; with 30 to 40 per cent it will melt at 180 deg. to 190 deg. C. A very easily fusible soft solder is made by melting together lead and tin and allowing the mixture to stiffen slowly. Before it is entirely hard the outer crust is broken in, letting out the fluid portion underneath; this is the so-called "liquidation solder." Galvanized metals are often added to color the tin solder, but they always raise the melting point.—Journal der Goldschmiedekunst.

Directions for Making Dog Biscuit.—The Pharmaceutische Zeitung of Berlin gives the following description of the manufacture of dog biscuit:

The waste portions of meat and tallow, including the skin and fiber, have for years been imported from tallow factories in the Argentine Republic, in the form of great blocks, and most of the dog bread made by modern manufacturers consists principally of these remnants, chopped and mixed with flour. They contain a good deal of firm fibrous tissue, and a large percentage of fat, but are lacking in nutritive salts, which must be added to make good dog bread, just as in the case of the meat-flour made from the waste of meat-extract factories. The flesh of dead animals is not used by any reputable manufacturers, for the reason that it gives a dark color to the dough, has an unpleasant odor, and if not properly sterilized, would be injurious to dogs as a steady diet.

Wheat flour, containing as little bran as possible, is generally used, oats, rye, or Indian corn being only mixed in to make special varieties, or, as in the case of Indian meal, for cheapness. Rye flour would give a good flavor, but it dries slowly, and the biscuits would have to go through a special process of drying, after baking, else they would mold and spoil. To make it keep well dog bread must be made from good wheat flour, of a medium sort, mixed with 15 or 16 per cent of sweet, dry chopped meat, well baked and dried like pilot bread or crackers. This is the rule for all the standard dog bread on the market. There are admixtures which affect more or less its nutritive value, such as salt, vegetables, chopped bones or bone-meal, phosphate of lime and other nutritive salts. In preparing the dough and in baking, care must be taken to keep it light and porous.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

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